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Abstracts of Principal Articles

The Manufacture of S.G.A. Air Control Valves .....P. 816

A new type of pilot- or solenoid-operated air control valve, now being made under licence in this country for Transmission Accessories, Ltd., Leighton Buzzard, by Austin S. Beech & Co., incorporates a stationary sleeve and moving plunger of stainless steel. Since the plunger is the only moving part, the valve has a long life, but the plunger must fit the sleeve bore very closely to provide an adequate seal. After being machined from bar material by set-ups on capstan lathes, the sleeves are taken to a bench machine, fitted with an automatic feed unit and a special fixture, on which 10 rows of 5 air passage holes are drilled. Hardening is then carried out in a controlled atmosphere furnace with an oil quench tank, and the components are next subjected to a temperature of — 65 deg. C. to ensure that most of the retained austenite is transformed to martensite. This treatment prevents subsequent dimensional changes in service. Tempering follows, and the sleeve bores are then honed and the outside surfaces centreless ground before they are used to control the diameters of the individual mating plungers. The latter are subjected to the same heat treatment procedure, and are ground on a machine fitted with special equipment whereby the diameter to which each plunger is ground is matched with the bore of its mating sleeve. A bore in the aluminium valve housing is sized by pushing a standard bearing ball through it. (MACHINERY, 92—11/4/58.)

Developments in Precision Bending Methods for Waveguides.....P. 824

Attention is drawn in this article to the increasingly exacting requirements for waveguides as regards both complexity and accuracy, and methods are described whereby various problems have been overcome. It is explained, for example, that it may be necessary to make allowance, in designing the tools, for the changes in tube wall thickness which occur at the bend, in order to avoid wrinkling. The advantages of compression boosting for small radius bends are also explained. Bends discussed include simple types in both the "easy" and "hard" planes, also compound forms, and diagonal plane and tuned mitre bends. Examples of articulated mandrels and other tooling components are described and illustrated. Details are also given of the somewhat elaborate press tools which have been developed for the finishing operations on tuned mitre bends of both 90-deg. and 45-deg. forms. (MACHINERY 92—11/4/58.)

Applications of the G.K.N. Spark Machine P. 835

After a brief description of the recently introduced G.K.N. spark machine, its application for the production of various cavities in hardened steel and other materials is discussed. The production of copper electrodes by the cold hobbing process is first considered, and the use of a set of electrodes, made in this manner, for spark-machining a cavity in a die for forging a small adjustable spanner is then described. Electrodes for spark-machining the profiles required in electric motor lamination dies are made by stamping blanks from copper sheet in an existing or specially-made tool, and mounting them on an arbor. Such electrodes may be employed for making stripper plates quickly and accurately. An alternative method for producing electrodes for cutting the aperture in a die, for example, for stator laminations, is to file copper blanks to shape with the aid of hardened templates. Spark machining has also been employed for cutting a cavity in a forging die employed in the manufacture of pedal pads with truncated four-sided pyramidal projections. Other operations described include the spark-machining of cavities or apertures in drawing dies, cold heading dies and gripping fingers for nail-making machines. (MACHINERY, 92—11/4/58.)

Examples of Fixtures Employed for Barrel-finishing .....P. 841

For barrel-finishing certain large or delicate parts, fixtures have been designed by the Lord Chemical Corporation, U.S.A., and here some examples are illustrated and described. When the work is held in a fixture, and the volume of chips is such that it is almost covered, only gentle abrasion of the surfaces takes place. A spoke-type universal fixture is provided with chains or rubber-covered bars on which the workpieces are loaded. Stainless steel straps for helicopters are processed in a cage-type fixture, and large heat-exchanger plates are held in position by means of slotted bars. (MACHINERY 92—11/5/58.)

Rowland Single-ended Horizontal Spindle Surface Grinders .....P. 843

F. E. Rowland & Co., Ltd., have recently supplied several single-ended, horizontal spindle surface grinders which incorporate certain basic units similar to those of their duplex machines. Special drum-type work-holding fixtures are incorporated, and the machines are intended for grinding single end faces of components, on a quantity basis, to close limits of accuracy. One of the machines described is equipped for grinding end faces of small pistons for motor-car brake assemblies, at the rate of 80 per min., and another is arranged to cut off surplus material and then face grind the ends of motor-car valve stems. (MACHINERY 92—11/4/58.)

Fosmatic Automatic Jig Borer with I.B.M. Punched Card Control System.....P. 848

With the control system applied to this machine, positioning of the work table in both directions, selection of spindle speeds and feeds, changing of cutting tools for different operations, adjustment of the spindle head for height, and control of the depth of bored holes, are entirely automatic. A separate system is employed for disengaging the rapid power traverse and engaging the feed during the downward travel of the spindle. The machine is employed for boring holes in side frames for business machines, to a centre distance accuracy of 0·0004 in. (MACHINERY 92—11/4/58.)

Developments in Plastic Deformation Processes

At the conference on Technology of Engineering Manufacture, recently held by the Institution of Mechanical Engineers, a wide field was covered, and numerous papers of high standard served to draw timely attention to the rapid advances that are constantly taking place in many directions. Ample evidence was thus again afforded—if it were needed—of the fact that our manufacturing industries can only remain competitive if the processes of re-equipment and introduction of new techniques are pursued with increasing vigour. Regardless of inconsistent financial policies of successive Governments, we cannot afford to mark time.

Attention has already been drawn in MACHINERY to certain papers of particular importance, and others will be considered in subsequent issues. As might have been expected, several of the authors were concerned with developments in plastic deformation processes which are likely to be increasingly adopted as a means of effecting substantial economies in the production of a wide variety of components.

In one paper, for example, reference was made to a process known as static-dynamic forging which is being investigated at Belgrade University, and is said to be yielding promising results. Briefly, with this method, a steady squeezing action is maintained by a hydraulic ram to which pressure is applied from an accumulator. Hammer blows are superimposed on this squeezing action by means of a tup, which is caused to reciprocate within the hollow ram. Tests have shown that the deformation of the work material, in a given time, is greater with this combination than when either the "static" or "dynamic" action is applied separately. In particular, it is stated, good material flow is obtained with static-dynamic forging, both in the direction of the applied forces and in the direction at right angles.

Another paper was concerned with the rubber diaphragm method of deep drawing and with the process termed "shear spinning" by the authors, which is more commonly known in this country as flow turning. Considerable information on both these methods has previously been published, but it appears that the advantages which they offer are not always fully appreciated. With the diaphragm pressing method, tooling costs are reduced so that fairly small batches can be produced economically, fewer operations are required than for conventional drawing, better finish is obtained, less experience is needed to obtain good results, very little thinning occurs so that the parts produced are stronger, and variations in stock thickness can often be permitted so that cheaper material can be used.

Flow turning enables important savings in material to be obtained, and facilitates the production of many parts which have previously presented difficulty. A good internal surface is ensured, so that tubes made by this method may be employed, for example, for hydraulic cylinders, without any finishing operations on the bores. In common with other cold deformation processes, moreover, flow turning increases the hardness of the material and improves the grain structure so that better shock resistance is achieved.

The potential importance of the impact extrusion process, particularly as applied to steel, is now widely recognized, and valuable work is being carried out by the Production Engineering Research Association to determine the effects of various factors on the results obtained. In a paper concerned with these investigations, it was pointed out that the method enables a material utilization of about 90 per cent to be achieved, whereas with orthodox machining methods the figure is frequently no more than 45-50 per cent. Here, again, owing to the improvement in physical properties which results from the cold working, highly stressed components can frequently be made from inexpensive low-carbon steels instead of the alloy steels that have been specified for machined parts. Accuracy and surface condition of impact extruded parts are such that very little finish machining is normally required, so that the process is economical as regards both plant and labour, in addition to material. It is emphasized, however, that if the full benefits are to be achieved, components must be designed with proper consideration for the limitations as well as the possibilities of the method.

Cold heading and upsetting processes, although principally associated with the production of a variety of standard fasteners, are rapidly finding increasing application for a diversity of components, usually as an economical preliminary to machining. It was stated, in a paper on this

(*Continued on page* 869)

The Manufacture of S.G.A. Air Control Valves

Air control valves of novel design are now being manufactured in this country, under licence from Numatico, Inc., Michigan, U.S.A., by Austin S. Beech & Co., Leighton Buzzard, Beds., a new company formed for the purpose on behalf of Transmission Accessories, Ltd., Leighton Buzzard, Beds. As described in MACHINERY, 90/665—22/3/57, these valves, an example of which is shown in Fig. 2, incorporate sleeves and plungers of hardened and stabilized stainless steel, and their design is covered by U.S. patents No. 576,990 and No. 576,991. Patents are pending in all other countries. As seen more clearly in the sectional view, Fig. 1, the sleeve is held in a cast aluminium housing and has a series of annular projections, in each of which a groove is machined to receive an O-section sealing ring. The projections are provided at positions corresponding to plain portions of the bore in the aluminium housing, and air passages communicate with the bore at intermediate points. Between adjacent projections there are drilled holes in the sleeve so that air can pass from one cast passage to another, depending on the position of the grooved plunger. The air passages emerge at the underside of the housing, which is mounted on a base unit, with a gasket to form a seal. Since connections are made to this base casting, the valve unit may be removed easily, for servicing, without disconnecting any pipes. In addition to the base shown, manifold bases may be supplied for mounting a maximum of six valves, so that a very neat installation, with a minimum of piping, may be obtained.

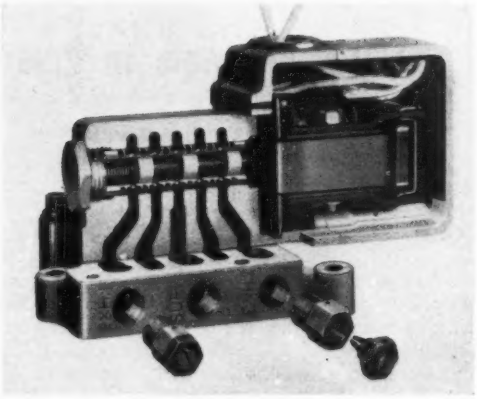

Fig. 2. Details of a Single-acting Solenoid-operated Valve with Spring Return may be Seen in this Cut-away View. The Provision of Two Exhaust Ports Enables Metering Valves to be Fitted for Speed Control

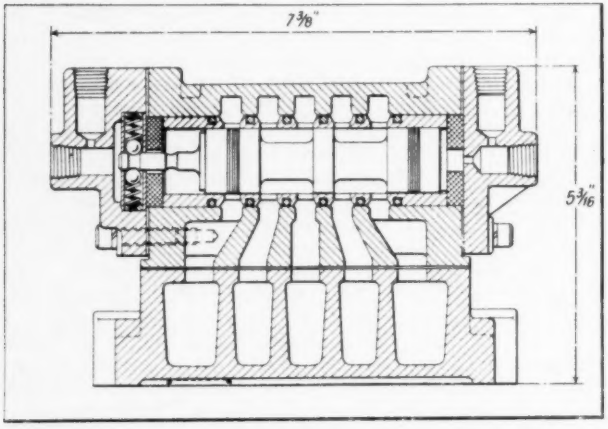

Fig. 1. Sectional View Showing the Arrangement of a Double-acting Pilot-operated Air Valve. An Extension to the Plunger has Two Grooves which are Engaged by Spring-loaded Ball Detents so that the Valve may be Mounted in any Position

The grooved plunger is a very close sliding fit inside the sleeve, and as it is the only moving part, and is hardened, the valve has a very long life. Since the O-ring seals are not subjected to movement, they do not usually require replacement during the life of the unit. For operation of the valve, one or two solenoids, of the quick-acting, continuously-rated type, are provided, to suit any specified voltage. A single-solenoid valve is shown in Fig. 2, and the double-acting type has an additional solenoid on the left-hand side. Alternatively, the valve may be pilot-operated, as in the example shown in Fig. 1, in which the air pressure from the pilot

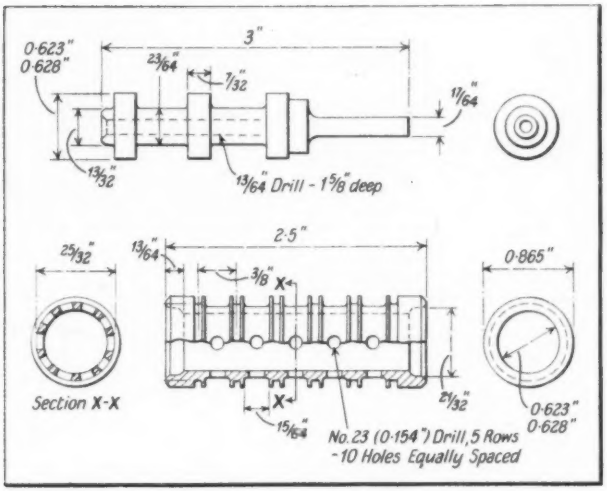

Fig. 3. Drawings Showing Details of the Sleeve and Plunger for the ⅜-in. Valve. The Sleeve Bore is Lapped Round and Parallel to any Dimension Within the Limits Shown and the Plunger is then Ground to Match it

valve acts directly on the end of the plunger. An extension at one end of the plunger has two part-circular peripheral grooves, and these grooves are engaged by spring-loaded balls to hold the plunger in position after it has been positively moved by the pilot valve or solenoid. This arrangement enables the valve to be fitted in any required position, without risk of the plunger moving from its setting under gravity. At present, valves are available for use with pipes having bores of ¼, ⅜, ½ and ¾ in., but other sizes will be included in the range shortly. Some of the more interesting of methods employed for the production of the valve components are described in this article.

Sleeves for valves which are to be employed with pipes of ⅜ in. nominal diameter are machined from a special stainless steel, supplied in the form of ⅞-in. diameter black bar. The main dimensions of a sleeve and a matching plunger, for a valve of this size, are given in the part-sectional drawing, Fig. 3, and it will be seen that the sleeve has an overall length of 2½ in., and four annular projections with grooves of approximately square-section for the O-ring seals, also two seal grooves in the end portions. The bore has a wide tolerance, since a plunger is matched to a finished diameter by grinding on a Studer machine fitted with a special attachment, as will be explained. The first operation on the black bar is carried out on a No. 4 Herbert capstan lathe, and a close-up view of the tooling is given in Fig. 4. After the bar has been fed to a stop, the outside diameter is turned with a tool in the 4-way turret at the front of the cross-slide (on the left), leaving a grinding allowance, and the end of the bar is centred with a tool in one of the turret-mounted holders.

A centre, at the next turret position, is then

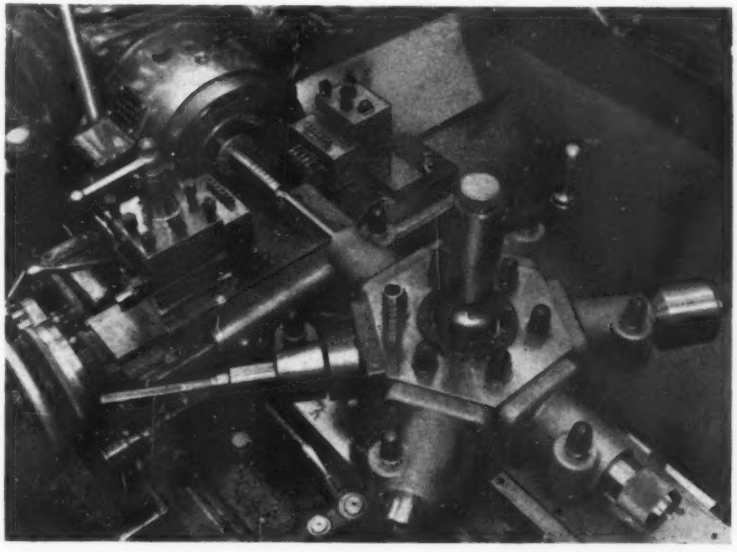

Fig. 4. Set-up on a No. 4 Herbert Capstan Lathe for Producing Sleeve Blanks from Stainless Steel Bar. Air Passage and O-ring Seal Grooves are Produced by Form Tools on the Front and Rear of the Cross-slide

engaged with the centre hole while the forming tools in the holder at the rear of the cross-slide are fed in to a depth of 0·042 in. Next, a second set of form tools, seen on the face of the cross-slide turret nearest to the work in Fig. 4, is advanced to cut the O-ring grooves to a depth of ⅛ in. With the cross-slide retracted, turret tools are then employed to drill the bar $\frac{41}{64}$ in. diameter, and bore and ream the hole to 0·620/0·621 in. diameter.

The straight-fluted reamer used is tipped with Wimet carbide—as are the turning tools employed for this set-up—and the boring bar is fitted with a Herbert Micro-bore carbide-tipped tool insert. For the boring and reaming operations, the spindle speeds are 620 and 157 r.p.m., and the feeds, 240 and 160 cuts per in., respectively, and the cycle is completed in 10 min., the work being parted off with a tool in the front cross-slide turret.

From the capstan lathe, the components are transferred to an adjacent capstan lathe for facing and chamfering at one end, and then to a bench drill on which the 10 rows of 5 air passage holes are drilled.

INDEXING DRILLING FIXTURE

For the drilling operation, the Pacera machine, shown in Fig. 5, fitted with an air-hydraulic automatic power feed unit is employed. This unit is controlled by the press-button valve at the right-hand side, which the operator actuates when he has indexed the component in the fixture to the position at which the next hole is to be drilled. The drilling operation is completed automatically after the button has been pressed, a pilot valve being operated which admits air to one side of the piston in the upper of the two cylinders at the side of the machine. The ram of this cylinder is connected by a rack to another piston in the further end of the cylinder, the space between this second piston and the end wall of the cylinder being filled with oil. A pinion on the feed shaft of the drill is turned by the rack and feeds the drill down, and oil is meanwhile displaced from the upper cylinder into one end of the lower cylinder, which also has two pistons connected together. The two cylinders are connected by a housing at the further end which incorporates the oil passages and adjustable restrictor valves to control the drilling feed rate. Just before the drill breaks through, another valve is brought into operation to reduce the feed rate, so that there is less risk of damage.

Direction of spindle travel is reversed when a pilot valve is operated by a projection on a collar attached to the feed shaft of the drill. The air supply is then transferred from the upper to the lower cylinder, and since there is no restriction to the flow of oil in the reverse direction the drill is rapidly retracted. The other hand-operated valve at the right in Fig. 5 is employed to reverse the direction of spindle travel in emergency, and it operates the main pilot valve of the unit.

Fig. 5. For Drilling 10 Rows of 5 Air Passage Holes in the Sleeve, this Pacera Bench Drill, Fitted with an Automatic Air-hydraulic Power Feed Unit, is Employed. Drilling is Completed in 9 Min.

A close-up view of the fixture in which the sleeve is held for the drilling operation is given in Fig. 6, where the top plate, carrying the five drill bushes, has been swung aside to show the work. The fixture incorporates a rectangular plate *A*, of mild steel, which rests on the base casting of the drill press, and is guided longitudinally by inverted L-shaped members at each side. The plate has five locating holes drilled near one edge, and these can be engaged by a plunger, fitted with a knob *B*, which is mounted in a housing on the guide at one side. With this arrangement, the plate can be indexed to positions ¾ in. apart after each ring of 10 holes has been drilled. At one end of the plate *A* there is a vertical steel block, with a horizontal bore housing a short

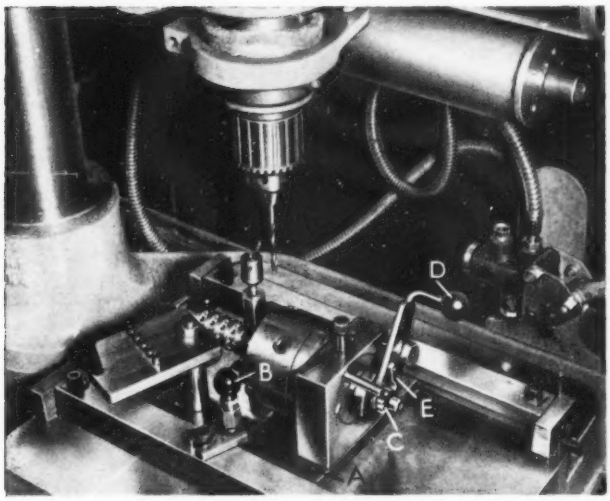

Fig. 6. Close-up View of the Drilling Fixture on the Machine in Fig. 5, from the Further Side. The Component, Held in a 3-jaw Chuck, is Indexed by Means of the Lever *D*

spindle. At the operator's end, the spindle carries a circular disc *C*, with 10 equally-spaced slots cut in its periphery. A lever D is mounted on the same spindle, behind the indexing disc, and its movements, round the spindle, are restricted by a stop at each side.

On the face of the lever, above the indexing disc, there is a small loose catch *E*, with a hooked end which can be engaged with one of the slots in the disc. The shape of the hooked end is such that when the lever is moved to the left the hook is lifted out of the slot in which it is engaged, and just before the lever makes contact with the left-hand stop, the hook drops into the next slot in the disc. When the lever is next returned to the right, the spindle is turned through 36 deg. to the position at which the next hole in the ring is to be drilled. The lever is held by the operator in contact with the right-hand stop, so that the spindle is positively located. Pressure is applied to the spindle by means of a friction pad, which can be adjusted by the screw at the top of the block, to hold it stationary during the movement of the lever *A* to the left.

On the side of the steel block remote from the operator there is a 3-in. capacity Burnerd chuck, in which the sleeve to be drilled is gripped. The outboard end of the sleeve is supported by a tailstock against the drilling pressure. A number 23 drill (0·154 in. diameter) is employed, at a speed of 1,500 r.p.m., and the 50 holes are drilled in a floor-to-floor time of 9 min. The bores of the sleeves are next reamed to remove the drilling burrs, and the components are then degreased in trichlorethylene to remove any traces of sulphur which might attack the surface during the subsequent hardening process, and prevent a good finish being obtained at the final grinding and other operations.

EFCO JUNIOR HARDENING PLANT

A close-up view of the Junior hardening plant employed for sleeves and plungers, which was supplied by the Electric Furnace Co., Ltd., is shown in Fig. 7. The

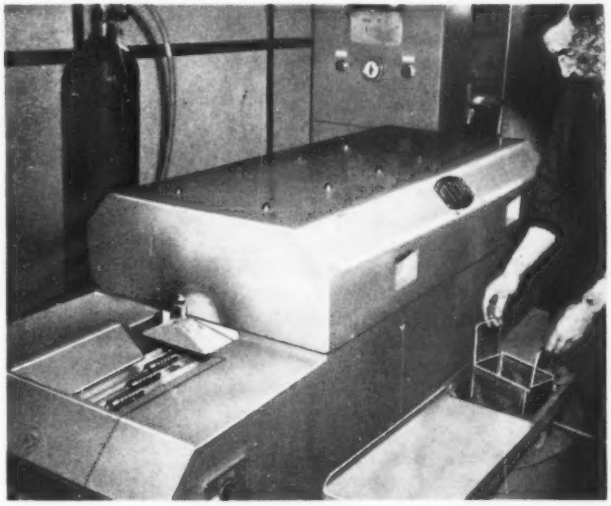

Fig. 7. Sleeve and Plunger Components are Hardened in this Efco Junior Shaker Hearth Furnace. Hydrogen Gas Surrounds the Heated Parts Until they Fall into the Oil-quench Tank

furnace has a hearth made of heat-resisting steel with longitudinal grooves which prevent the parts from rolling about. This hearth is 6 in. wide by 2 ft. 6 in. long and it extends into the heated zone of the furnace. A shaking motion is imparted to the hearth by means of a roller, which is held by springs in contact with a cam covered with hard rubber. The cam is driven by a variable speed motor, and has rises which are so designed as to move the hearth slowly forward and then to release it so that it returns rapidly. By adjusting the speed of the cam, it is possible to vary the time required for a component to pass along the length of the hearth from about ½ to 4 or 5 min. The hearth is surrounded by a muffle of nickel-chrome steel, which is supplied with hydrogen gas from a cylinder so that the heated parts do not come into contact with air. At the heated end of the hearth, the muffle is formed into a chute which extends downwards into an oil tank beneath the furnace.

When the heated components reach the end of the hearth they fall down the chute, which is also filled with hydrogen, into the oil. In this way, the parts are protected from the atmosphere during the entire heating and quenching cycle. In the circular, water-cooled, oil tank beneath the furnace there is a carrier which can be turned by means of ball handles attached to its sides, and in this carrier, immersed in the oil, there are four rectangular baskets of perforated material, each measuring about 8 by 6 by 15 in. deep. One of these baskets is seen being lifted from the carrier in Fig. 7, and it can then be stood on the chute in the foreground while the oil drains away. When the carrier is in the correct position for removing one basket, another, at 90 deg., is located beneath the end of the muffle chute, ready to catch the parts as they enter the oil. The furnace is heated by means of electrical resistance elements, and temperatures up to 1,150 deg. C. can be obtained.

For hardening, the sleeves are placed on the hearth in a staggered arrangement as shown in Fig. 7, so that they reach the heated zone one at a time and each is thoroughly heated. The temperature employed for the operation is 1,050 deg. C., which is maintained by an automatic controller in a separate cabinet, safety units being fitted to switch off the current should the controller fail and the temperature rise excessively. The speed setting for the shaker cam is set to the lowest value so that the components remain in the furnace for approximately 5 min., to ensure that they are thoroughly heated before being quenched. The treatment is designed to impart a hardness of 61 to 63 Rockwell C to both components.

LOW-TEMPERATURE HEAT-TREATMENT

After the hardening operation, it is necessary to reduce the temperature of the components, within a short time, to −65 deg. C. As explained in MACHINERY, 85/603—17/9/54 the complete transformation of austenite into martensite in an alloy steel is not completed by quenching the material to room temperature. If it is allowed to remain at room temperature after being quenched, for an appreciable period, the retained austenite becomes stable and it is then more difficult to effect the transformation to martensite. Periods as short as one hour may have a detrimental effect. Although 100 per cent transformation can only be achieved by repeated chilling and tempering treatments, only one such treatment is found to be necessary for valve sleeves and spindles, and for the first stage, the Prestcold low-temperature refrigerator unit, Fig. 8, is used. This unit was described in MACHINERY, 85/447—27/8/54, and it is equipped

Fig. 8. To Ensure that the Transformation from Austenite to Martensite is Sufficiently Complete to Prevent Dimensional Changes in Service, the Sleeves and Plungers are Cooled to −65 deg. C. in this Prestcold Low-temperature Unit

with a twin-cylinder 2-stage compressor unit, driven by a 2 h.p. motor. Arcton 6 is employed as a refrigerant, and the heat exchange medium is water. This unit is capable of maintaining temperatures within the range of −20 to −65 deg. C. in the chamber of the plant. In Fig. 8 the operator is seen placing a basket of components in the chamber, access to which is obtained by lifting an insulated hinged lid. The chamber measures 21 by 10½ by 16 in. deep, and it is partially filled with methylated spirit, which is cooled to the temperature mentioned above. When the components are immersed in the liquid, they are rapidly cooled, and, to ensure that the transformation is as complete as possible, they are held at this temperature for a minimum of 3 hours.

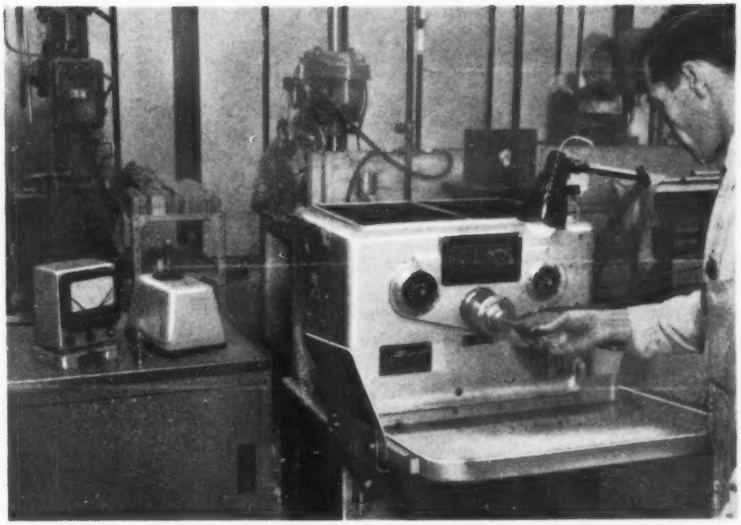

Fig. 9. Sleeve Bores are Lapped on a Delapena Machine with a Single Stone. Roundness and Parallelism are of More Importance than Diameter at this Operation

After the low-temperature treatment, the components are again degreased, and they are then tempered in an oven, at a temperature of 180 deg. C., for 2 hours. The treatment described not only increases the hardness of the components and ensures that this hardness is more uniform throughout, but also prevents subsequent dimensional changes in the parts, which are very accurately finished, as will be described. If such changes occurred, they would cause endless difficulties in the operation of the closely-fitting parts.

Tempered valve sleeves are sand-blasted to remove heat-treatment discolouration, and are then lapped in the bores on the Delapena machine shown in Fig. 9. At this operation, approximately 0·005 in. of material,, on the diameter, is removed, to bring the bore within the limits of 0·623/0·628 in. specified. The hone is driven at a speed of 380 r.p.m. and is fitted with a single stone of D-C8-C specification. The operation occupies up to 10 min., depending on the amount of distortion of the bore during the hardening operation. Inspection of the bores is carried out with the Movolimit (Matchless Machines, Ltd.), equipment seen at the left in Fig. 9, which is capable of detecting taper and out-of-roundness of the bore in amounts as small as the 0·00002 in. or less specified for these imperfections in sleeve components. The finish inside the bore is also of high quality, a maximum roughness of 5 micro-inches being specified. The Movolimit equipment is also employed in connection with the final grinding of the plungers, as will be explained. To complete the series of operations on the sleeves, they are passed to a centreless grinder on which the outside diameter is finished to 0·865/0·869 in., to suit the housing bore of 0·875/0·876 in. diameter.

OPERATIONS ON PLUNGERS

Comparatively few operations are required on the plunger component, details of which are given in Fig. 3. It is machined from black bar of ¾ in. diameter, of the same specification as the material employed for the sleeves, and the initial stages, carried out on a No. 4 Herbert capstan lathe, include feeding to a stop, centre drilling, turning the outside to 0·637/0·640 in. diameter, forming two wide grooves to ⅝ in. diameter and the ½-in. diameter, turning the stem to ⅜ in. diameter, and parting-off. The cycle time for this set-up is 7 min. A second lathe is then employed to face the end, turn the ½-in. diameter, and drill the central hole ⅜ by 1⅝ in. deep. The plungers are then subjected to the same cycle of degreasing and

heat treatment as applied to sleeves.

After heat treatment, the plungers are shot-blasted, and they are then passed to the Studer (Matchless Machines, Ltd.) universal machine shown in Fig. 10, on which they are ground on the outside diameter to limits of 0·627/0·628 in., as a preliminary to final grinding. This latter operation is carried out on the same machine, with the set-up shown in Fig. 10, the diameter to which each individual plunger is ground being controlled by a particular sleeve, selected arbitrarily. The Movolimit equipment, mentioned earlier, is employed in conjunction with the Studer machine for this matched grinding operation, and is shown in the close-up view, Fig. 11. This equipment includes a unit, seen at the right, with a vertical arbor to suit the size of the sleeve. Within the arbor there are measuring plungers, which are pressed inwards as the sleeve is placed in position, and register the size of the bore.

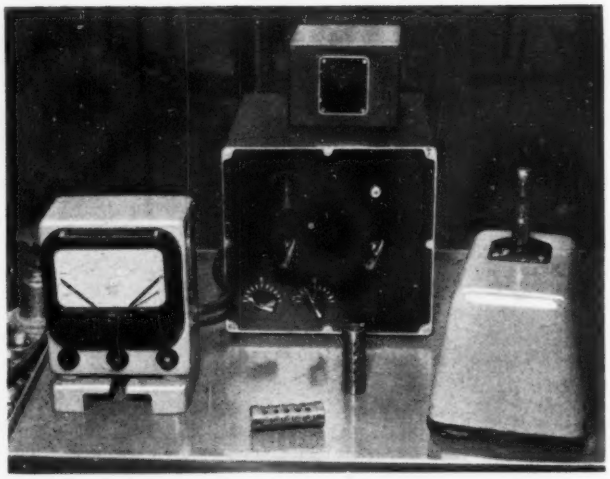

Fig. 11. Details of the Movolimit Equipment for Matched Grinding of Plungers. The Sleeve is Placed on the Measuring Mandrel at the Right and the Plunger is Automatically Ground to Give the Correct Clearance

The table of the grinding machine carries the Movolimit head, which is moved forward hydraulically to bring a fixed and a moving contact into engagement with the workpiece. The contacts are fitted with sapphires to minimize wear, and they register the diameter of the workpiece continuously during the grinding operation. This Movolimit head is connected to the indicator unit on the left in Fig. 11, which has two scales, one graduated in 0·00001 in. and the other in 0·0001 in. divisions. The sensitivity of the head can be changed by moving a switch on the control cabinet at the centre in Fig. 11. With the equipment shown, the diameter of the workpiece can be ground to provide a clearance (of a given amount within very close limits) in the bore of the sleeve which has been placed on the measuring arbor. For the valve sleeves

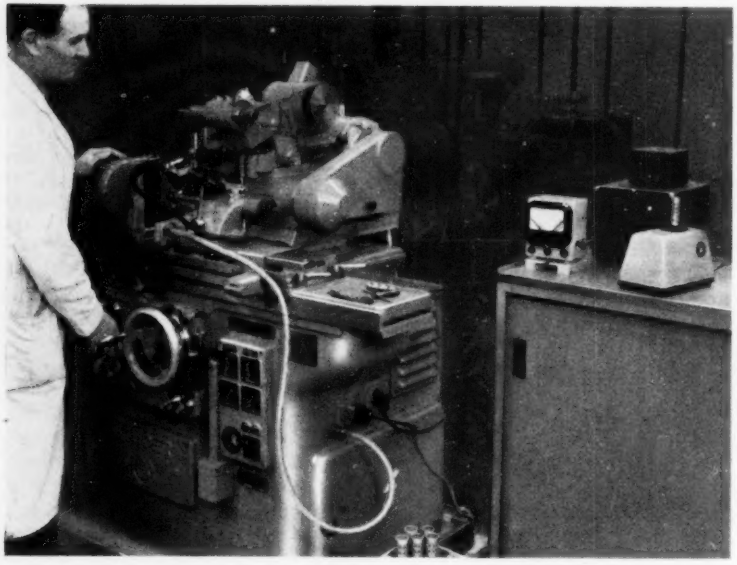

Fig. 10. Valve Plungers are Finish-ground on this Studer Universal Machine, Fitted with Movolimit Automatic Sizing Equipment

and plungers here considered, the clearance is held to a tolerance of 20 micro-inches. In addition to matching two components in this manner, the equipment can be employed to grind parts to a pre-set constant diameter, by adjusting one of the knobs on the control cabinet.

On the Studer machine, a steplessly variable drive to the work-spindle is provided by means of a Ward-Leonard set housed in the base, and for the plunge-finishing operation a spindle speed of 400 r.p.m. is employed. The coolant employed is Codol (Metal Working Lubricants, Ltd.) soluble oil, which is diluted with water in the proportions of 70 to 1, and is circulated through a Filtrox filter, supplied with the machine, which ensures that very fine particles are removed.

BALL-SIZING AN ALUMINIUM BORE

Valve housings for the stainless steel sleeves are cast in aluminium alloy, and the various operations, which include milling the joint faces, and drilling and reaming the cored hole to receive the sleeve and its O-ring seals, are carried out by conventional methods. This bore is finished by pushing through it a standard hardened bearing ball of the appropriate diameter, and for this purpose the equipment shown in Fig. 12 is employed. A double-acting air cylinder of 5-in. bore and a stroke of 8 in., is secured in a vertical position to a channel-section upright. The end of the ram is fitted with a plunger which can enter the bore to be sized, and a braced platform is provided to support the work. A ball is placed on top of the bore, and the casting is then positioned beneath the ram by hand, before the air valve in the foreground is operated to bring down the ram. The operation sizes the bore to 0·875/0·876 in., and also serves to push down any machining ridges and to smooth the bore surfaces so that a better seal is obtained. It may be noted that the control valve employed is representative of a new range, comprising hand-, foot-, and cam-operated types, which will shortly be introduced.

Fig. 12. For Accurately Sizing and Smoothing the Bore which Accommodates the Sleeve in the Cast Aluminium Valve Housing, a Standard Bearing Ball is Pushed Through it with this Equipment. A Sectioned Housing is Seen at the Right

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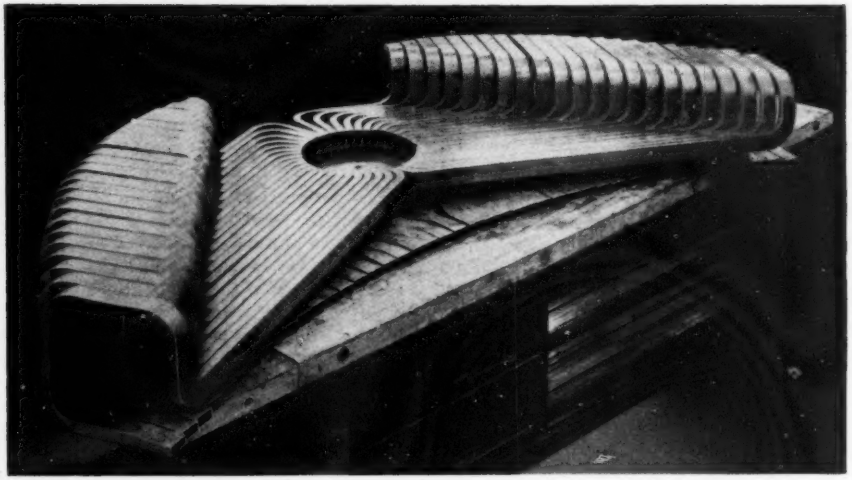
NEW PROCESS FOR THE ELECTROREFINING OF NICKEL.—Research scientists and engineers of The International Nickel Company of Canada, Ltd., have developed a new process for the electrorefining of nickel. A main feature of the process is the direct electrolysis of nickel matte and artificial sulphide, whereas with the usual electrorefining methods a metal anode is used. The new Inco process eliminates high-temperature oxidation and reduction operations, with attendant losses of metals and sulphur and selenium. Instead, nickel sulphide of low copper content from the Bessemer converter or other source can be cast directly into sulphide anodes and electrolyzed for the production of high quality nickel. Another feature of the process is that it permits, for the first time in nickel refining, the commercial recovery of elemental sulphur and selenium as valuable by-products, in addition to cobalt and precious metals which are conventionally recovered.

It is stated that International Nickel now recover 14 elements from the ore mined, namely nickel—of which the company is the world's largest producer—copper, cobalt, platinum, palladium, rhodium, ruthenium, iridium, gold, silver, iron, tellurium, selenium, and sulphur.

ENGINEERS' SMALL TOOLS AND INSTRUMENTS, produced during the third quarter of 1957 in the U.K., had an average monthly value of £5,546,000, and equipment to the average value of £788,000 per month was exported. For the first and second quarters of 1957, the corresponding figures were £5,634,000 and £840,000, and £5,991,000 and £898,000 respectively.



Developments in Precision Bending Methods For Waveguides

By F. J. FUCHS*

With the rapid development of radar and other microwave equipment there has been a need for parallel development in associated manufacturing technology. One phase of this technology is concerned with the production of accurate, and often complex, waveguide channels, whereby high-frequency microwaves are manipulated for the purpose of transmission, measurement, and control.

At first, shop techniques were not unusual because mechanical requirements were not too exacting. Later, as higher degrees of performance were demanded, more rigid specifications were imposed on waveguides, such as those shown in Fig. 1, until the demands for mechanical precision exceeded the capabilities of normal shop methods. Variations of internal dimensions around the bend were not permitted to exceed ±0·003 in. At the same time, it was necessary to avoid scratches on these inside surfaces which might result in arcing under high loads.

* Western Electric Co., Inc., U.S.A.

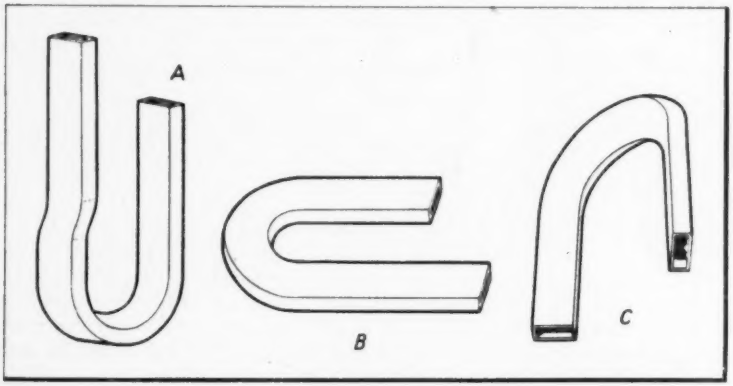


Fig. 1. Some Examples of Precision Waveguides

ANALYSIS OF WALL THICKNESS

A careful analysis of material flow in a simple waveguide bend was first made. From this study it was learned that tubing distorted in certain predictable

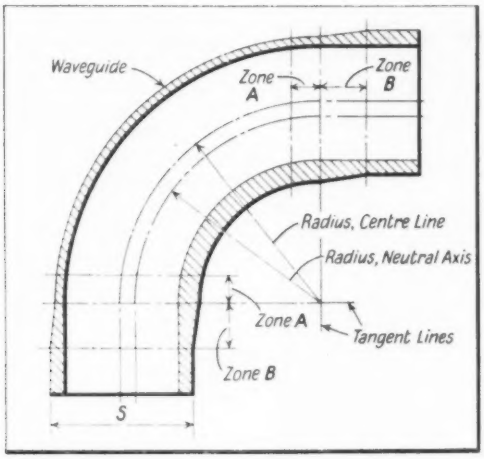


Fig. 2. Distortion of Wall Thickness when Bending Waveguide Tubing is at a Minimum at the Beginning (right) of Zone *B*, and is at a Maximum at the End (left) of Zone *A*

patterns, and that the location and intensity of the distortion could be estimated accurately as a preliminary to designing the necessary tools. This information is of great importance, since every change in wall thickness and other distortions will have an effect on the internal cross-section of the tube.

As in the bending of any rod or tube, the bent waveguide is thrown partly into compression and partly into tension about a dividing line termed the neutral axis. The part of the tube in tension must stretch, so that it becomes thinner in cross-section, and the part in compression must shorten, so that the section becomes thicker.

Thickening at the inside, and thinning at the outside, continue along the straight portion of the tube for some distance beyond the tangent line at both ends of the bed, as indicated by zone *B* in Fig. 2. Zone *A* extends beyond the tangent line into the curve and represents that portion not subject to the full elongation and compression effects. The amount of distortion in zone *A* is less than the distortion at the centre of the bend by the amount of material distorted in zone *B*. In other words, the wall thickness distortion due to bending rises from a minimum at the beginning of zone *B* to a maximum at the end of zone *A*.

These zones include the only portion of the tube under active stress at the time of bending, where the metal of the tube is in a state of flow on both sides of the tangent point. This area is critical since tools must be designed to guide the flowing metal and restrict distortion so that the necessary inside dimensions will be preserved. It should be pointed out that many of the techniques described in this article are covered by patents.

MAKING SIMPLE BENDS

Bending dies used for simple radius bends consist of the six elements shown in Fig. 3. The form die *A* and clamping die *B* constrain the tube and rotate around a common centre. A top plate *C* and bottom plate *D* also constrain the tube and rotate around the same centre. The wiper die *E* and pressure die *F* constrain the tube, but are applied only sufficiently tightly to prevent distortion and wrinkling, so that the tube can slip

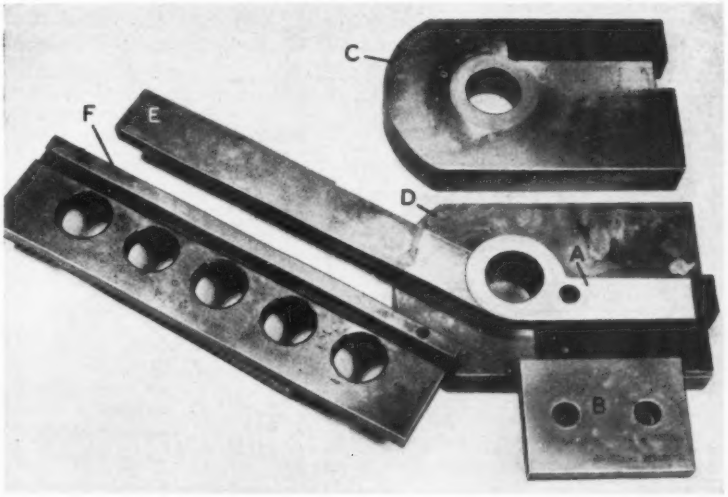


Fig. 3. A Precision Bending Tool for Making a Simple Bend Incorporates the Six Components Shown. The Form Die *A* and Clamping Die *B* Grip One End of the Tube and Rotate About a Common Centre

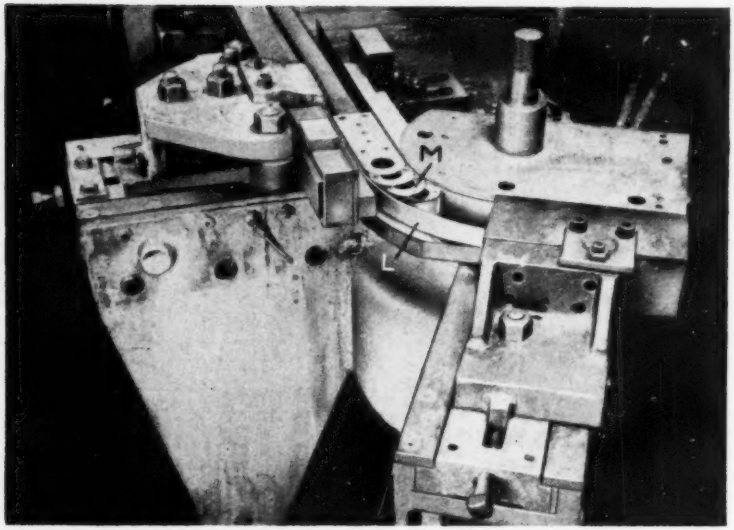


Fig. 4. One Wall of a Waveguide has been Cut Away to Show an H-plane Mandrel in the Working Position. The Top Die Plate of the Bending Machine has Also been Removed

between them while being drawn around by the other members.

A die arrangement of this type is employed on a Pines hydraulic bender. This high-speed machine operates on an automatic cycle and will produce up to 100 bends per hour. By means of a 7½-h.p. electric motor, a 2,000-lb. per sq. in. hydraulic pump and main cylinder, and a large chain and sprocket, a bending moment of 4,500-ft.-lb. is developed. Auxiliary cylinders are used for mandrel insertion, for operating various tube clamps, and for closing dies.

For producing a simple bend, the solid portion of an articulated drawing mandrel is inserted into the tube up to the point of tangency with the die radius. As the tube is bent by rotation of the form die and clamping die, the articulated links follow the curved form, but the mandrel remains stationary. During bending, the tube is enclosed on all sides.

A long mandrel extractor permits the bend to be made up to 8 ft. from one end of the tube. During high-production runs, the top die plate is automatically secured by a hydraulically-operated toggle clamp. Screw-clamps are used when the production rates are lower.

An H-plane bend (*B*, Fig. 1) is shown positioned on the Pines bender in Fig. 4. For purposes of illustration, the top die plate has been removed and the waveguide tube *L* cut away. The working position of the flexible mandrel *M* may be clearly seen.

A common fault of the type of bending tool just described lies in the wiper die and the straight portion of the form die. If the surfaces facing the tube are made flush with the rounded part of the form die, the material at the inner wall of the tube will build up and force the mandrel stem outward.

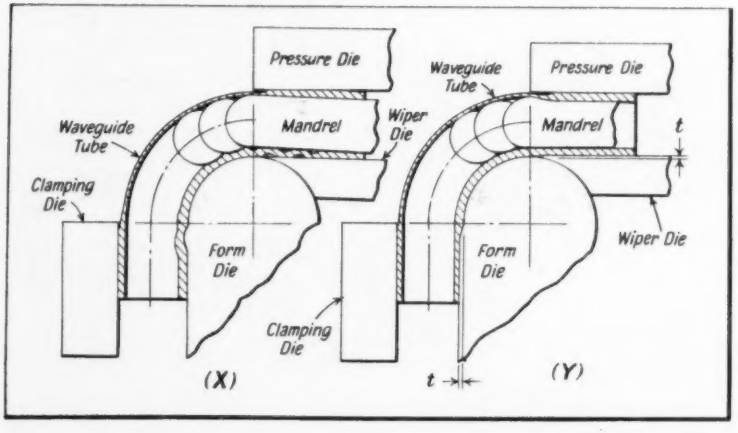


Fig. 5. In a Simple Bending Tool, the Faces of the Wiper and Form Dies Should be Offset by the Amount *t* in View *Y*, Representing the Increase in Tube Wall Thickness. Wrinkling of the Inner Wall, as Indicated in the View at *X*, is thus Avoided

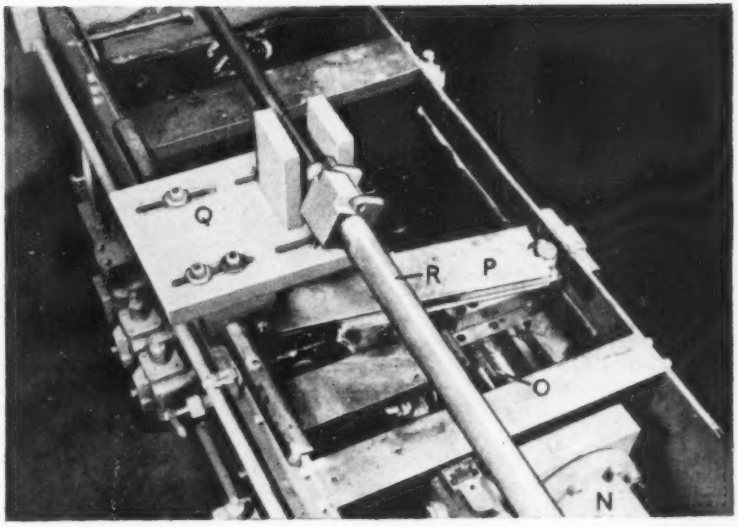


Fig. 6. This Boosting System for a Bending Machine is Actuated by the Main Bending Cylinder *N*. Through an Adjustable Linkage, the Brass Tube *R* is Forced Against the End of the Waveguide which is being Bent

Wrinkling will then result, as indicated in the view at *X* in Fig. 5, apart from the fact that an undue strain is imposed on the mandrel.

By offsetting the wiper die face and form die face by the amount of the increase in tube wall thickness, as indicated by *t* in view *Y*, interference is avoided and a smooth bend is obtained. Both the top and bottom plates of the die should also be contoured to allow for side-wall thickening at the inner radius. All surfaces which come in contact with the waveguide should be hardened, ground, and polished, to minimize friction and wear.

COMPRESSION BOOSTING FOR SMALL-RADIUS BENDS

When the radius of bend is small in proportion to the tube size—less than 1·5 S for an H-plane bend, where S is the large dimension of the waveguide—the tube cannot be bent without breaking, unless provision is made for compression boosting.

Due to severe stretching of the outer tube-wall during small-radius bending, fracture will occur unless precautions are taken. To reduce this tension, pressure is applied to the end of the tube while bending is in progress, so that the cross-section is placed under some degree of compression. The effect is to shift the neutral axis towards the outside of the bend, so that there is less tension in the outer wall.

Boosting has proved so helpful that considerable time has been spent in developing a system that is effective and permits of easy adjustment. Fig. 6 shows a successful boosting arrangement installed on a Pines bender. The bending cylinder *N* is used to provide the pressure required. As the piston-rod *O* moves out, it causes a large adjustable cross-arm *P* to pivot. The left-hand side of this cross-arm is connected to a sliding block, *Q*, which serves as a mounting base for the portion of the booster that presses against the waveguide. By adjusting the pivot point of the cross-arm, movement of the block can be varied from zero to 10 in. Brass tubing *R* of suitable length is placed on the mandrel rod to connect the booster with the end of the waveguide.

When boosters are used with simple waveguide bending dies, the extent to which the neutral axis

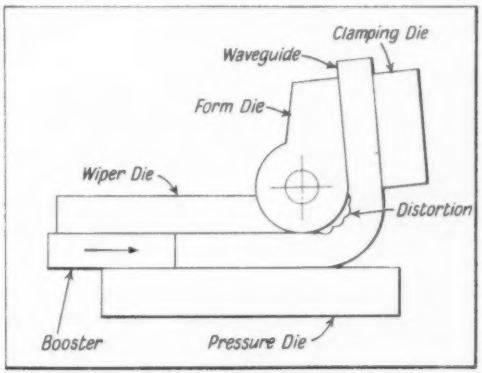


Fig. 7. When Compression Boosters are Used with Simple Bending Dies, the Extent to which the Neutral Axis can be Displaced is Strictly Limited. Too Much Pressure Will Force the Tube Away from the Form Die, as Shown

can be displaced is considerably restricted. If too much pressure is applied to the tube it will be forced away from the form die and become distorted, as indicated in Fig. 7.

The small-radius bending die seen in Fig. 8 has a chain-like constraining member *T*. This member is keyed into the top and bottom plates and holds the tube against the former *U* during bending. The booster can then be used more effectively for the production of small radii, because additional compression can be safely applied. As a result, greater displacement of the neutral axis can be obtained, and the tension in the outer wall is correspondingly lessened.

With small waveguides, the bend radius is sometimes so sharp that it is impractical to fasten the tool to the machine with a stud that serves as the pivot point for the form die. Moreover, as the radius decreases, the wiper die is not sufficiently supported at its sharp end. In such circumstances, a modified design of standard die is employed.

An example of a die used to bend a ⅝- by 1¼-in. tube in the H-plane to a zero radius is shown in Fig. 9. The bottom plate is bolted to the machine head and centred by means of a locating ring, and the form die and the top plate are fastened, in turn, to the bottom plate by bolts and dowels. Top and bottom plates are also provided for the wiper die. These plates fit against the top and bottom plates of the form die in the same manner that the standard wiper die fits against its corresponding form die.

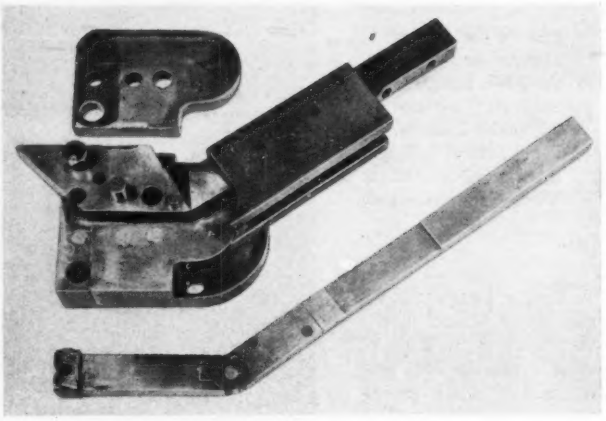


Fig. 9. One Type of Tool Used to Form a Zero-radius Bend in the H-plane. The Bottom Plate is Bolted to the Machine Head and Centred by Means of a Locating Ring

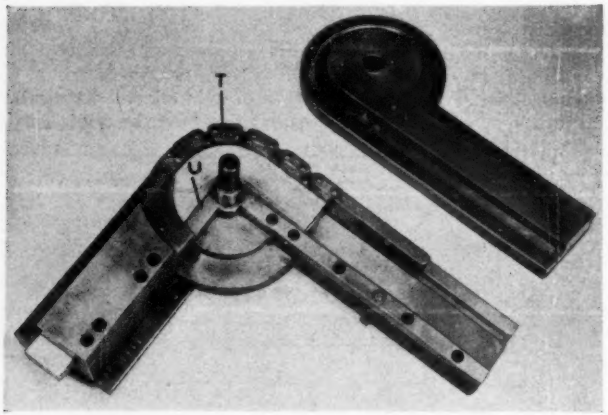


Fig. 8. This Bending Tool for a Small Radius is Designed for Use with a Compression Booster. The Chain-like Constraining Member *T* Holds the Tube Against the Form Die to Permit More Efficient Use of the Booster

TOOLING FOR BENDS IN THE E- AND H-PLANES

Tools to be used for E-plane bends (*A*, in Fig. 1) and those for H-plane bends (*B*, Fig. 1) differ as regards several points of design. One difference that may not readily be observed is due to the more pronounced tendency for wrinkling to occur in the wider wall of the tube during bending. This wall lies against the form and wiper dies when an E-bend is being made, and against the top and bottom plates during H-bending. Consequently, when the tool is for an E-bend, the wiper point and form die must be contoured much more accurately. In the case of an H-bend, however, it is the top and bottom plates that must be accurately contoured.

The problem of wrinkling, and the degree of tool accuracy necessary, to maintain tube smoothness, depend to a great extent on the relative wall thickness of the waveguide. If the ratio of tube size to wall thickness is

high, the tube will wrinkle easily. On the other hand, if the ratio is low, the walls are more rigid and wrinking is less likely to occur.

The reason for wall distortion will be evident when it is pointed out that the tube is supported by the mandrel links at points that are some distance apart. If the tube wall is thin, "oil-canning" is liable to take place between the links. When designing tools for precision bending, therefore, it is necessary to consider the relative wall thickness in order to determine the accuracy necessary for contours and the spacing of mandrel links.

There are wide variations in the relative wall thicknesses of waveguides. For ½- by 1-in. tubing the value is 20:1, whereas for 1½- by 3-in. tubing it is 37·5:1. Thus, as would be expected, large tubing is more likely to wrinkle.

The degree of finish necessary on a bending die and mandrel depends to some extent on the material to be bent. For softer materials, a smoother finish is required, especially on the mandrel, to prevent galling of the interior surfaces. The mandrels are usually made from Nitralloy steel.

For simple E- and H-bends, two types of mandrels have been standardized. The E-bend mandrel, shown at *X* in Fig. 10, is made up of one-piece links that fit into each other and are connected by pivot-pins. The stem of the mandrel is shaped to provide maximum support at the tangent line.

It can be seen from the illustration that the joints become progressively smaller towards the front end of the mandrel. With this design, a wall can be provided between the front cavity and the rear counterbore, which greatly strengthens the link. The joint adjacent to the straight stem is proportioned so that the pivot-pin is slightly weaker in shear than the link is in tension. Consequently, in the event of breakage, only the pin need be replaced.

Accuracy of mandrel construction is important, and this applies especially to the fitting of the joints. If a joint is slightly out of parallel, it will be subjected to a one-sided stress during the bending operation and will be liable to break. The mandrel is finished to a size that is 0·001 in. larger than the specified minimum inside dimensions for the waveguide tube.

Links for the standard H-bend mandrel, shown at *Y* in Fig. 10, are constructed in interlocking pairs. One member of each pair is keyed to the mating link for alignment, and to prevent shifting, which would result in scoring of the waveguide.

Spacing of the links is limited to one-half the link diameter, and this has proved satisfactory for all radii and for all sizes of tubing. In some cases, however, where this design is used for E-bends in large tubing, the link adjacent to the stem is provided with a curved projection at the back, to prevent wrinkling. A mandrel of this type is shown at *Z*. When the link is in a bent position, the projection fills the gap that would normally be present just in front of the stem. A link of this design can be used for one radius of bend only.

In theory, the waveguide tube need only be supported as far as the end of zone *B* (Fig. 2), for at no time is the tube stressed beyond this point. In practice, the flexible portion of the mandrel is made longer—the minimum corresponding to the larger dimension of the waveguide. In some cases, where no booster is used, the E-bend mandrel is considerably longer. The H-bend mandrel never has more than four links, and as few as two have been used successfully in conjunction with a booster.

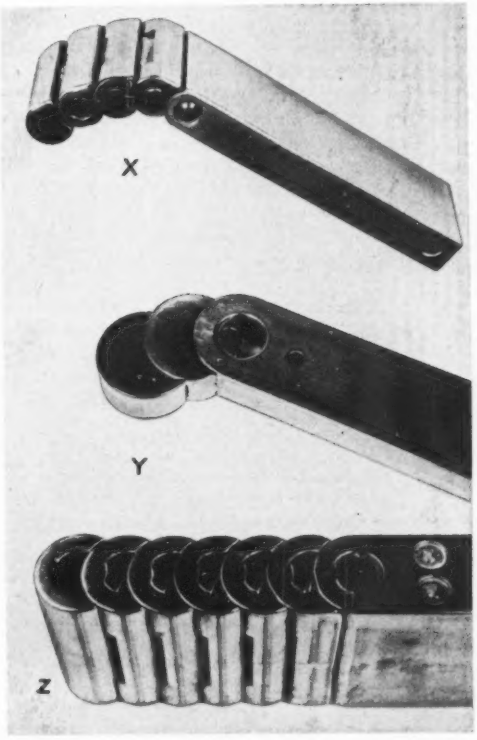


Fig. 10. Standard Mandrels for E-bends (*X* and H-bends (*Y*). A projection on the First Link of the Mandrel at *Z* Prevents Wrinkling when Forming a Large E-bend

SLIDING FRICTION MUST BE REDUCED

During the bending operation, the waveguide is drawn off the close-fitting mandrel, with the result that much friction is involved. The important factors for reducing the drag are the type of lubricant used and the manner in which it is applied.

Several lubricants were tested to compare their effectiveness. This test involved pressing a brass sample between steel plates so that the pressure exerted on it ranged from 5,000 to 30,000 lb. per sq. in. The force necessary to cause the sample to slide was then recorded. In Fig. 11 are shown the results of several tests with different lubricants.

Castor oil, although obviously less effective, is used for light work because of the ease with which the finished tube may be cleaned. Wax is employed for medium-heavy bending operations, and white lead for all heavy bending, especially of aluminium. Whichever lubricant is applied, it must be distributed evenly for a distance of several inches along the inside surface of the tube, at the end through which the mandrel enters.

Correct annealing of the waveguide tube in preparation for bending is also important. If the tube is annealed for too long a period, a rough "orange-peel" surface is likely to result where the metal is strained. Annealing is carried out in a salt bath whenever possible, to permit accurate control of time and temperature and to avoid oxidation.

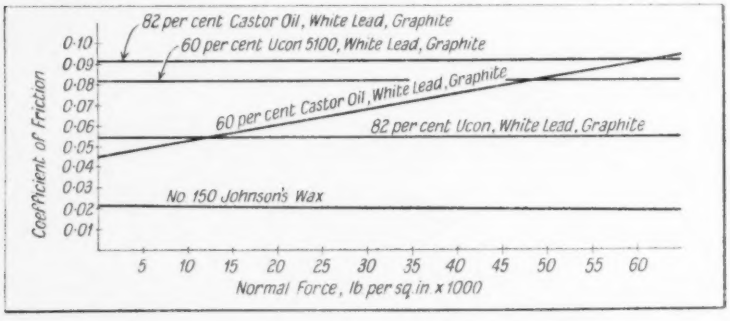


Fig. 11. Graph Showing the Results of Numerous Tests to Determine the Most Suitable Lubricant to be Employed Under Different Bending Conditions. White Lead is Used for All Severe Operations, Particularly on Aluminium. The Values are for Sliding Friction of Brass on Steel

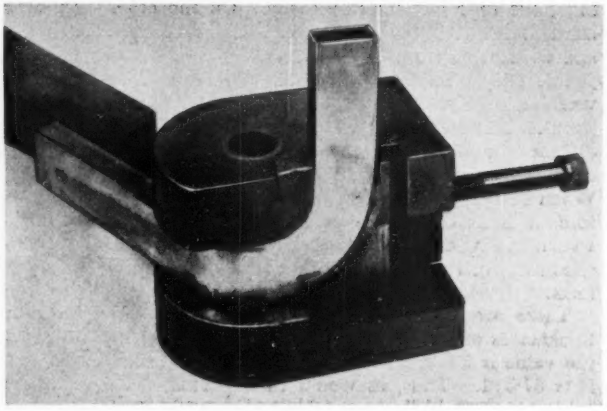


Fig. 12. One Method of Clamping Waveguide Tubing when Producing a Compound Bend. For Small Quantity Production, Cerromatrix Inserts are Used to Grip the First Bend so that the Second Bend can be Formed

After the annealing operation, the waveguide tubing is cleaned in an acid dip. This cleaning process is important because it enables the tube to be inspected more readily for flaws that are sometimes revealed after annealing. It is also found that the lubricant adheres better to a clean surface, and that there is much less wear on the mandrel when the tubes are clean.

THE PROBLEM OF COMPOUND BENDS

One of the difficulties of waveguide production is concerned with precision compound bends. Frequently, a tube has several bends spaced sufficiently far apart to be considered as separate simple bends. This type of tube presents little trouble.

Compound bends become difficult when the straight sections between bends are too short to permit adequate clamping. From this standpoint, the minimum length of straight section is three times the large dimension of the guide. The closer together the bends, the greater the difficulty.

Externally, the problem is one of nesting and clamping. Internally, when the bends are so close that the straight section is less than the flexible mandrel length, the links must turn in the direction of the nested bend as well as the bend to be made. An example of nesting and clamping for closely spaced bends is shown in Fig. 12.

With bends that are nested, allowance must be made for the build-up in wall thickness. This allowance is provided by contouring the steel nest when the die is to be used for large-quantity production. For limited quantities, it has been found desirable to use Cerromatrix inserts. If the bends are very close together, however, and of extremely small radii, a Cerromatrix insert will not be strong enough to enable even a small quantity of guides to be produced. In such circumstances, it is necessary to provide a floating clamp that tightens against tapered sections when the clamp-die slide moves into position.

Perhaps the most spectacular example of precision bending is the "organ pipe scanner" shown in the heading illustration. There are 44 waveguides, each with six multiple bends of varying degrees in both the E- and H-planes. No two are alike, although half of the waveguides are mirror images of the remainder. For these guides, a standard radius was selected for all bends. A left-hand bending machine was acquired, since, after three bends have been made, the direction of bending must be reversed to prevent interference between the tube and the tooling. The necessary mandrels and dies were then constructed.

After the tooling had been proved, extensive data were obtained for the growth in length versus angle of bend. Once this information had been charted, the designers were able to estimate and lay out the group of waveguides so that the resultant electrical length of all guides would be the same. This work was checked experimentally for four typical pieces, representing a sample of the 44 different guides. Only then was it possible to proceed with the construction of tooling to produce the complete array.

MANDRELS FOR COMPOUND BENDS

For closely-spaced compound bends, mandrel design requirements are exacting. If compound bends are in the same plane—both E-bends or both H-bends—the standard E- or H-mandrel can be used by cutting additional clearance in the links to allow for bending in two directions. When the bends are in different planes, the mandrel employed for the second bend must flex upwards at the end in order to enter the existing curvature.

If the radii of the bends are sufficiently large—1·5 S or greater—a mandrel of the type seen at *X* in Fig. 13 can be used. This mandrel comprises a set of links curved on all sides and held together by a steel cable. Should the bend radii be too small, the cable will break.

For radii between 1·5 S and 1 S, a mechanically jointed mandrel, such as that shown at *Y*, is employed. To prevent marking of the tubing by the side joints, it is preferable to use this mandrel to make the H-bend after the E-bend has been completed.

It should be noted that the strength of these mandrels is considerably less than that of the simple E- or H-type. Owing to this lack of strength, the radii of compound bends cannot be less than 1 S when they are tangent to each other. With wider spacing, the bends may be made smaller. If bend spacing is greater than the length of the flexible mandrel, the compound bend can be considered as two simple bends as regards curvature, although special nesting and clamping may be required.

The tube at *Z*, in Fig. 13, has an E-bend tangent to the larger end of a tapered section. Thus, the mandrel must be tapered from the starting centre line forward. If the tube were merely

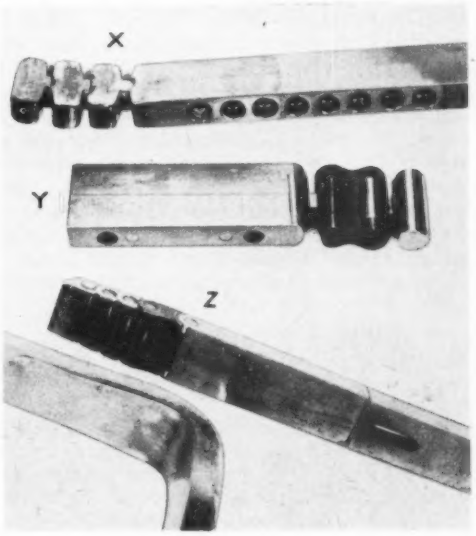


Fig. 13. Some Standard Mandrels Used for Compound Bends. The Mandrel at *X* has Formed Links Joined by a Steel Cable. A Mechanically-jointed Mandrel is Seen at *Y*. The Special Mandrel at *Z* is Designed for Bending a Tapered Tube

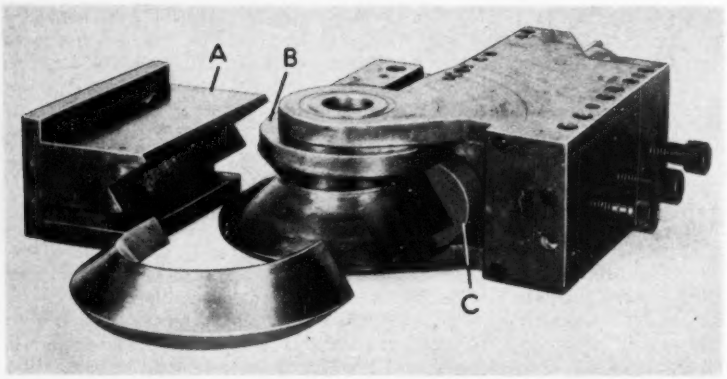


Fig. 14. Tooling Used for Bending and Twisting to Produce a Skew Bend. *A*—Clamping Die. *B*—Helix Form Die. *C*—Pressure Die. Bending can be Performed in Any Plane, and the Twist may be as Much as 10 deg. per inch of Centre Line

drawn off the mandrel, as usual, it would collapse because of the taper on the links. To overcome this difficulty, the main mandrel link is made extra long, with an inner surface that fits the form, and is allowed to float with the bend for a distance equal to the spacing between the pins. While the mandrel is floating, the back of the bend does collapse, but when the drawing action starts, the wall is pushed out by the end of the main link.

It is sometimes necessary to re-anneal the tube where two adjacent small-radius bends are required. In these circumstances, it is an advantage to anneal up to the previous bend only. Such local annealing can be obtained by controlling the depth to which the tube is immersed in the salt bath. Since the first bend will then remain hard, it is less apt to distort when the new bend is made.

It is important that the bends should be cleaned before re-annealing or assembly. Careful flushing in a degreasing agent has been found necessary to ensure a clean internal surface.

A recent innovation in waveguide bending is the diagonal-plane, or skew, bend, as shown at C in Fig. 1. The problem first arose in connection with a folded waveguide instrument where it was necessary for the waveguide to turn 180 deg., and re-enter after a 90-deg. twist. Waveguide openings are at right angles to each other and the axial centre lines are parallel.

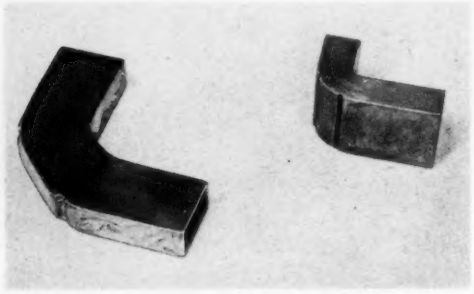


Fig. 15. Examples of Tuned Mitre Bends that have been Produced by Cold-forming. The Bend at the Left is in the H-plane, and the Bend at the Right in the E-plane

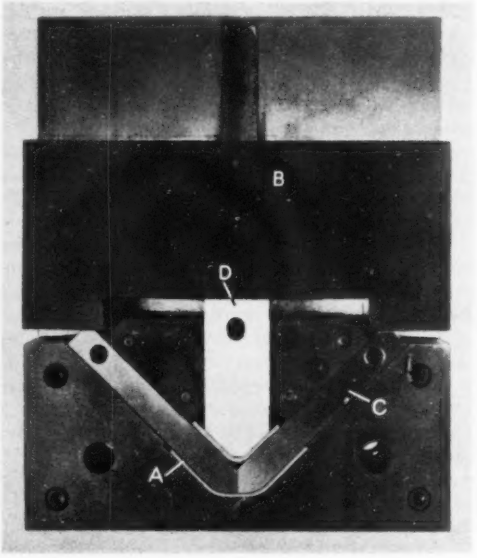


Fig. 16. After it has been Bent to Approximate Shape, a Mitre Bend is Subjected to a Preliminary Forming Operation in a Simple Bending Die

Actually, a 180-deg. bend is required, starting on a plane at 34 deg. to the horizontal. Its centre line is on a true arc. It is therefore possible to mount the pressure and wiper dies in pillow blocks, so that the trailing edge of the tube can twist. Tooling for the skew bend is shown in Fig. 14. Bending can be performed in any plane, and twist up to 10 deg. per inch of centre line can be obtained.

Wall-thickness increase in the skew bend is unpredictable. A slight allowance for this increase is made in designing the die, and any necessary tool corrections are made after the first few bends have been completed.

Mitre bends, examples of which are seen in Fig. 15, present a manufacturing problem. Not only are the dimensions critical, but the required form, with sharply intersecting planes,

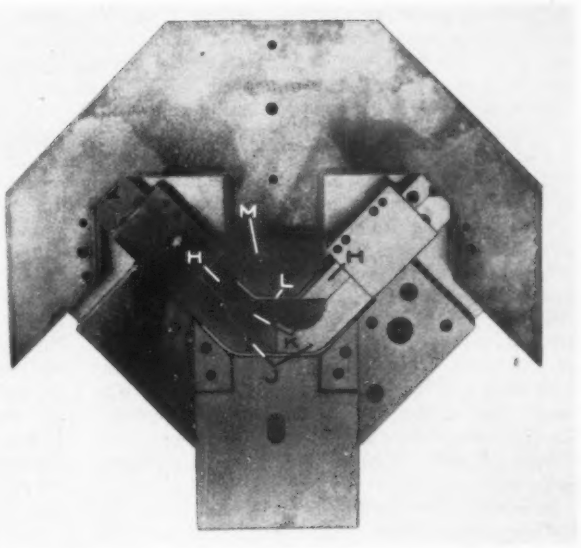


Fig. 18. Tool for Flattening the Inner Radius of an H-plane Mitre Bend from the Inside. Semi-circular Mandrel Inserts are Rotated Slightly by Wedges

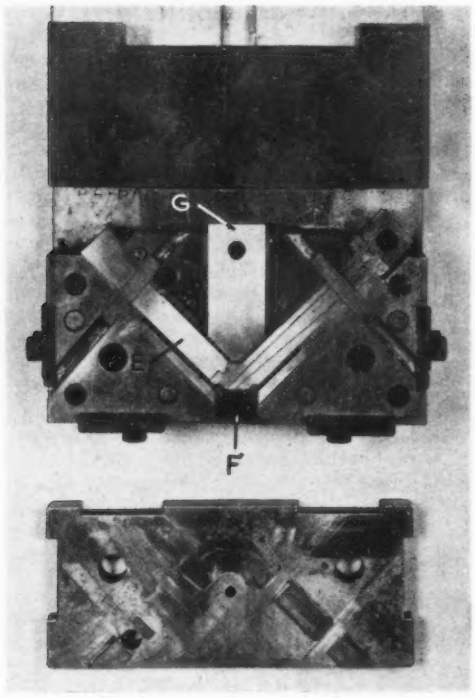


Fig. 17. The Second Stage Forming Tool for an E-plane Precision Mitre Bend

precludes the use of draw bending. These parts can be made by mitring, casting, or electroforming. Cold-forming from straight waveguide tubing is, however, also being carried out successfully.

At the right in Fig. 15 is shown a 90-deg. E-bend formed in a copper waveguide tube. First, the tube is bent on a ¾-in. radius die, cut to length, cleaned, and re-annealed. A simple forming die, as shown in Fig. 16, is employed to flatten the outer wall of the bend and reduce the size of the inner-wall radius.

The waveguide *A* has been cut away to show the tooling. As the pressure-block *B* is advanced, two mandrel sections *C* are forced into the tube. These sections flatten the outer wall of the bend. At the same time, the forming tool *D* is moved in against the inner radius, to semi-form that area.

After this operation, a split mandrel *E*, Fig. 17, is inserted in the waveguide, a dimpling punch *F* is placed in the die, and a contoured punch *G* replaces the previous punch for the inner corner. Two lock-bars hold the sections of the split mandrel in position.

The inner punch *G* has two radii located at the corners of the bend. The centres of these radii coincide with the corners of the bend inside the tube. Their effect is to crowd the metal displaced

by the sharp projections into the corners. In this way, a sharp break is obtained at the inside of the waveguide where a rounded corner would otherwise be formed.

Because of the larger cross-section of an H-plane mitre bend, an example of which is seen at the left in Fig. 15, it is possible to flatten the inner radius from the inside. This flattening is accomplished by turning semi-circular mandrel inserts by means of wedges. The wedges *H*, Fig. 18, are forced home after the main mandrel sections *J* have been locked in position. As a result, the semi-circular inserts *K* are turned slightly and flatten the inner section of the tube *L* against the form-block *M*. After flattening has been carried out, the main mandrel sections are replaced by sections provided with dimpling forms, also sliding sections that move just sufficiently to avoid the re-entrant corners behind the dimples. The dimpling punch is then placed in the die and the final operation performed.

In addition to the 90-deg. mitre bend, there is a 45-deg. mitre bend. Both bends are made by similar methods. Because of the smaller angle of the 45-deg. mitre, however, it is possible to start with a zero-radius bend (Fig. 9).

The forming die (Fig. 19), used to complete the mitre bend, is similar to the 90 deg. H-forming die (Fig. 18) in that a rotating member sizes the inner corner of the bend. The mandrel assembly *N* is inserted in the bent waveguide *O* (which has been cut away for clarity). With a synchronized movement, the wedge *P* is advanced into contact with the form-block *Q*, urging it slightly to the left against the outside of the inner-bend wall. The wedge *R*, which is housed within the mandrel, actuates the pivoting form-block *T* to force it against the inside of the inner-bend wall. Consequently, the inner-bend wall is sized by sandwiching it between the mandrel *N* and the pivoting form-block *T* on the inside, and the form-block *Q* on the outside.

A third wedge *U* advances, and forces the dimpling punch *V* into the outer corner of the bend to form the impression, as shown. This punch is backed up by a dimpling die *W* attached to the offset end of the mandrel. The wedge *U* is self-locking and is released only on withdrawal of the mandrel. It will be noted that the tube is supported both inside and outside, and it can therefore be formed very accurately.

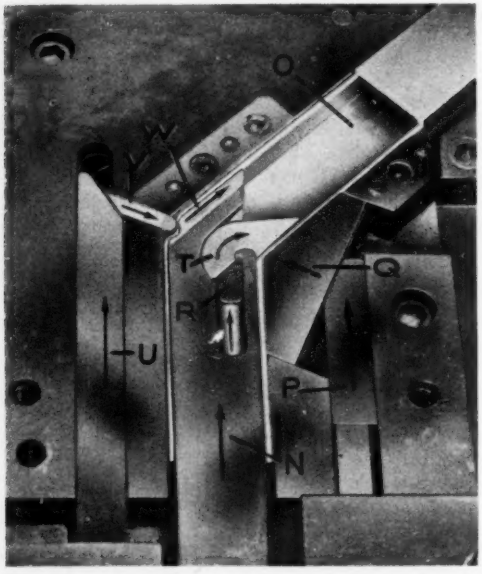


Fig. 19. Forming Tool Used for Finishing a 45-deg. Mitre Bend

B.S.A. Superland Reamers

Most sizes from the wide range of high-speed steel reamers made by B.S.A. Tools, Ltd., are now supplied with super-finished lands on the flutes, which have a surface finish of the order of 2 micro-inches. Known as Superland reamers, they are claimed to ensure improved surface finish and dimensional accuracy of reamed holes, and owing to the super-finishing, tool life is increased.

The Superland range covers hand reamers from ¼ to 2 in. diameter; machine reamers of ¼ in. diameter with parallel shanks and from ⅜ to 3 in. with Morse taper shanks; machine jig reamers and chucking reamers from ¼ to 2 in. diameter with taper shanks; chucking reamers from ¼ to ½ in. diameter, with a parallel shanks; and shell reamers and shell drills from 1⅛ to 4 in. diameter. Other items in the range include reamers with parallel and taper shanks for machining Morse taper sockets from No. 3 to No. 6; taper pin reamers from ¼ to 1 in. diameter, for hand and machine use; boiler makers' reamers from ⅛ to 1½ in. diameter; and high-speed steel counterboring and countersinking tools.

In addition, hand, machine and boiler makers' reamers, also chucking reamers, shell reamers and drills, and taper pin reamers, with super-finished lands, can be supplied in a variety of metric sizes.

B.S.A. reamers are distributed by Burton Griffiths & Co., Ltd., Small Tools Division, Montgomery Street, Birmingham, 11.

Applications of the G.K.N. Spark Machine

The G.K.N. spark machine, developed by the research laboratory of Guest, Keen & Nettlefolds, Ltd., for operations on hard materials such as cemented carbides, was described in MACHINERY, 90/1478—28/6/57. This machine is built by Welsh Metal Industries, Ltd., Caerphilly, a member firm of the G.K.N. Group. Fig. 1 gives a close-up view of the top of the cabinet and the working area of the machine. The cabinet houses a storage tank of 25 gal. capacity for the dielectric fluid, which is circulated by a pump, a by-pass filter being included in the system. A sheet metal basin, within the opening in the top of the cabinet, surrounds the work-table, and serves to retain the dielectric fluid when cutting is in progress. The work-table is 12 in. square and is provided with rows of threaded holes so that workpieces may easily be clamped in position. Behind the table, there is a column which supports the work-head, and another view of this head, from the left-hand side, with the covers removed, is given in Fig. 2.

As seen at the right, the arbor which carries the electrode is fitted with a V-block at its lower end, so that electrodes with cylindrical shanks may easily be secured in position with a standard stirrup-type clamp. Attached to the V-block is a flexible cable, which passes over two pulleys and is connected to a weight inside the support column, so that the arbor is counter-balanced and can be moved vertically with a minimum of effort. The arbor is of cylindrical form, with a wide flat surface machined on one side, whereby the drive is transmitted. Two widely-separated pairs of ball races, carried in brackets on the support column, provide guidance for the arbor, which is thrust against them by a spring-loaded driving roller. This roller can be turned, by means of the knurled plastics knob, for adjustment of the electrode height when setting up.

During cutting operations, the roller is driven, to lower the arbor at a controlled rate, by the small Klaxon geared D.C. motor unit at the left. The drive is taken from the output shaft of the unit, through a friction roller, to a disc *A*. This disc has an annular groove, and facing it there is another disc *B*, with a similar groove, carried on the end of the arbor driving-roller shaft. Between the two discs there is a flat plate with a number of holes housing bearing balls, which engage the disc grooves and transmit the drive. A small shaded-pole A.C. motor, mounted on the support column, carries a cam on the lower end of its spindle, and a projection from the upper side of the plate containing the bearing balls is held in contact with this cam by a tension spring.

Thus, when the spindle of the second motor is running, the plate and the bearing balls are oscillated slightly, and this oscillation is imparted to the final drive shaft and to the electrode carried by the arbor. The oscillation is of great assistance

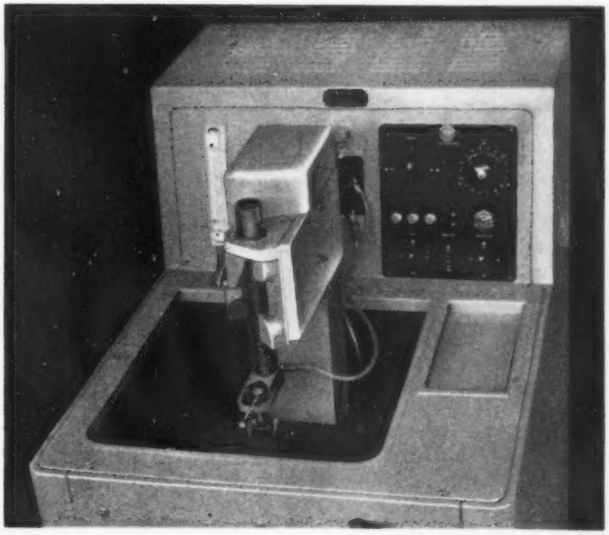


Fig. 1. The G.K.N. Spark Machine has a Sheet Metal Cabinet with an Aperture at the Top for a Tank which Encloses the Work-table and a Column for Supporting the Electrode Head

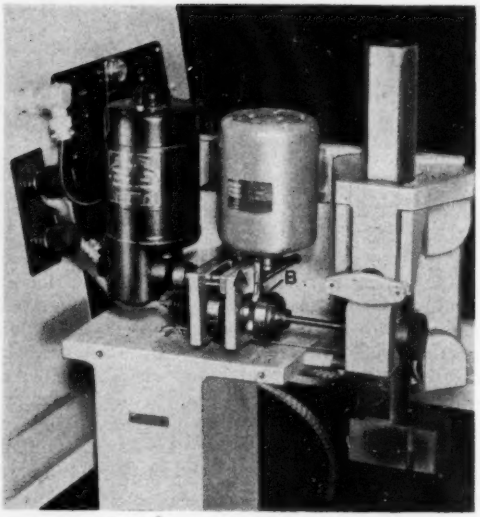


Fig. 2. In this View, from the Left-hand Side, of the Electrode Driving Mechanism on the G.K.N. Spark Machine, the D.C. Geared Motor Unit for Lowering the Electrode is Seen at the Left

when starting a cut, especially when the adjacent surfaces of the electrode and the work are substantially flat, or when operating in a deep cavity.

With an input capacity of 2 kW., the machine is normally arranged for operation on a 400/440-volt, 3-phase system, although it may be supplied for other voltages if required. Current to the driving motor at the left in Fig. 2 is supplied through a servo system designed to maintain a gap of constant size between the end of the electrode and the face of the work. According to the setting of the machine controls governing the feed rate of the arbor and the magnitude of the current applied, this gap will vary between 0·0015 and 0·003 in. The use of friction driving mechanisms which are free from backlash avoids instability in the servo system, and consequent variations in the size of the gap. As a safety precaution, only the table is connected to the positive supply, the remainder of the machine, including the arbor and electrode, being earthed. Special provision is made in the design of the electrical circuit to reduce the tendency for arcing to occur, and no valves or other electronic units are used in the spark-generating or servo systems.

The control panel at the right-hand side of the cabinet in Fig. 1, has switches for the pump which circulates the dielectric fluid, and for the generator and vibrator circuits. There is also a 4-position switch for controlling the quality of the finish obtained by altering the size of condenser in use, and a multi-position switch for adjusting the cutting rate by varying the current supplied to the work. A lamp on the panel indicates that the generator is switched on, and another lamp indicates instability of the spark during cutting. The maximum distance between the work-table and the underside of the V-block for the electrodes is 9¼ in., and the arbor has a total working travel of 6 in.

Electrodes for spark-machining are normally made from copper, although other materials, such as brass, may be used in special circumstances. With a copper electrode, the ratio of electrode wear to stock removal varies from 0·13 to 0·3 : 1, according to the current applied. The higher ratios are obtained with thin electrodes and those which have large cutting areas. In general, a tolerance of 0·002 in. can easily be maintained, depending on the shape and condition of the electrode, and closer limits can usually be held if necessary. With a standard of surface finish which is acceptable for most purposes, about 75 cu. mm. (0·0045 cu. in.) per min. can be removed, with a gap between the electrode and the work of about 0·0025 in.

Where large numbers of similar electrodes are needed, for example, for making or servicing of forging dies, for which the process is very suitable, they may be produced cheaply by first cutting a die cavity of the required shape and accuracy on a conventional die sinking machine. This die is then hardened and finished in the normal manner, and may subsequently be employed for producing large numbers of electrodes by the cold hobbing process, assuming that a press of sufficient capacity is available. A typical die, for producing electrodes to be used in the spark-machining of forging dies for the manufacture of adjustable spanners with an overall length of approximately 6 in., is seen at the extreme left in Fig. 3. Beneath the die is a copper electrode, made from it by cold hobbing. The process is quite straightforward, and the first step is to prepare a copper blank of a thickness which will provide sufficient material for the projections and leave an adequate supporting platform.

After it has been annealed, the blank is placed on top of the impression in the master die, and is then forced into the cavity in a hydraulic press exerting a load of about 50 tons per sq. in. of electrode area. Quite deep forms can be produced in this way. For a component such as the spanner, which has a maximum depth of about ¼ in., a minimum of three electrodes is required to sink one cavity.

Holes are next drilled and tapped in the platform area of the electrode so that the cylindrical shank, which is provided with a flange, may be attached approximately at the point of balance. Any recesses in the electrode, such as the square depression at the right-hand end of the spanner form, which might tend to trap gases formed during the spark-machining operation, are vented by drilling small diameter holes through to the rear face. At the rear, certain of these holes are connected to a length of tubing through which the dielectric fluid from the pump is delivered. Fluid is thus led directly into the cavities and flows out round the edges.

In sinking a die such as that required for spanner forging operations, one electrode is first employed to rough out the cavity, using the maximum metal removal settings of the machine. When only a small amount of material remains to be removed, this first electrode is replaced by another, so that those areas which have been left high, due to erosion of the first electrode, may be machined. Finally, the third electrode is employed to finish the cavity with a machine setting which gives the quality of finish required. The last electrode normally removes only 0·003 to 0·004 in. from the cavity surfaces. For the spanner die shown in Fig. 3, this procedure is completed in a period of about 6 hours, but the time could be reduced by rough machining the cavity, especially where the form is largely defined by straight lines. In making a second die, the first of the original electrodes is discarded, and the second is employed to start the new cavity. The original third electrode is employed for the semi-finishing operation, and a new electrode for finishing the cavity to size. A close-up view of a completed spanner forging die showing the quality of the finish is given in Fig. 4.

Fig. 4. Close-up View of a Cavity in a Forging Die for a Small Adjustable Spanner Produced by the Spark-machining Process, Showing the Quality of the Surface Finish Obtained

An alternative method of making electrodes is illustrated at the right in Fig. 3, where an electrode for cutting stripper plates for use with dies for electric motor laminations is seen. A number of copper laminations was blanked by means of the previously-made punch and die. These laminations were mounted on an arbor, as seen at the right in Fig. 3, and were clamped together securely, to form an electrode with which the stripper plate was cut. The stack of laminations was of sufficient length to enable the complete form to be cut in a single operation. It will be clear that the same method can be used to copy any existing blanking tool, providing the use of a stack of blanks as an electrode will give a finished tool of sufficient accuracy.

A taper of about 0·002 in. per inch of depth is normally produced on all sides of such a die opening, and

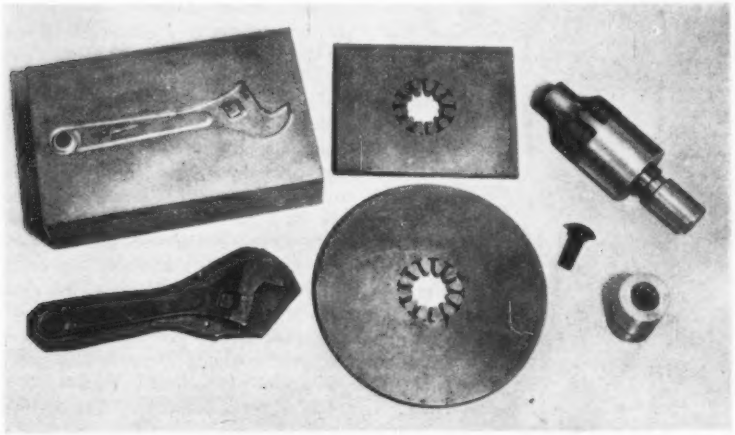


Fig. 3. (Left) A Completed Die for the Production of Electrodes from Copper Blanks by the Cold Hobbing Process, and an Electrode. (right) An Electrode Made from Copper Sheet Laminations, for Spark-machining Stripper Plates (centre)

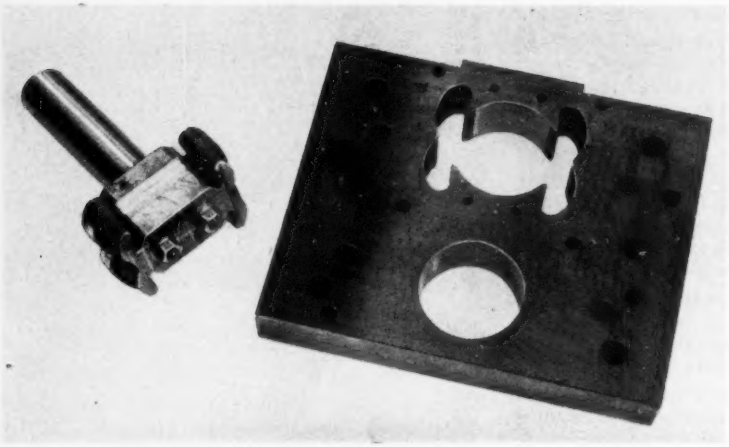


Fig. 5. A Die for the Production of Field Laminations for a Small Electric Motor with the Electrode Employed for Finishing the Blanking Aperture. This Electrode was Made from Copper Plates, Filed to Shape with the Aid of Templates

machining is carried out with the die plate inverted so that this taper can be utilized for clearance in the completed tool.

A cold-heading die for forming the square shank under the head of a coach bolt is seen at the lower right in Fig. 3, together with a bolt. Another example of a die, for the field laminations of a small motor, is shown in Fig. 5, also the electrode employed for cutting the aperture. This electrode is made up from a number of pieces of ⅜-in. thick copper sheet, each of which was produced by filing with the aid of hardened templates.

Two of these templates were made, with matching dowel holes, and after cutting the copper plates to the approximate size, and drilling and reaming dowel holes in the appropriate positions, one template was clamped to each side of a plate, with the dowels inserted, in readiness for filing.

Before the aperture was finish-cut, all the other holes required in the plate, which is of 1-in. thick die steel, were machined, and the aperture was drilled and roughly sawn to shape on a bandsaw, leaving about ⅛ in. on all surfaces. The plate was then hardened and tempered, and after it had been ground on all surfaces, was set up for spark-machining the aperture, which was completed in a period of about 3½ hours.

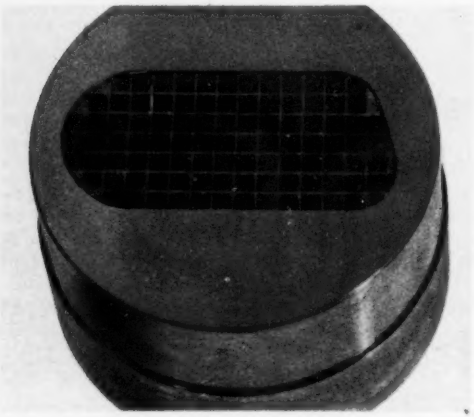


Fig. 6. Close-up View of the Cavity of a Spark-machined Die for Forging Pedal Pads. The Truncated Pyramidal Cavities Would Normally be Hand-cut with Chisels

Another forging die, for the production of pedal pads, is shown in Fig. 6. This die has rows of cavities of truncated pyramidal form, which provide projections of similar shape on the forged pad. These projections cover an area measuring 4 by 2 in. The die cavities must have sharp edges and since it is difficult to produce them by conventional machining techniques, they are normally cut by hand with die sinking chisels and similar tools. In the example shown, the cavities extend to a depth of about ¼ in. below the die surface, and their production by hand cutting is a laborious and lengthy process, which greatly increased the cost of the completed die. If only one such die were required, the electrodes could be prepared by machining copper blocks, the male form being much more easily produced. For a number of dies, it would be preferable to adopt the method described earlier, a master die being hand-cut and electrodes made by the cold hobbing process. The die cavity shown in Fig. 6 was sunk in a period of 12 hours, using three electrodes in the manner explained above.

A drawing die for steel bars of special cross-section, comprising a rectangle with a semi-circle

at one side, is seen in Fig. 7, together with the four electrodes employed for cutting the aperture. The first electrode used is seen at the extreme left, and this electrode cut through the blank from the back, a pilot hole having been drilled in the blank before this stage, to remove some of the surplus metal. This electrode finished the parallel portion of the die, and the direction of cut provided a slight back relief from the throat. Next, the die was inverted and three other electrodes were applied successively to form the taper section of the die with an angle of 8 deg. on each side. The amount of erosion on each of the three electrodes may be observed in Fig. 7, where the electrode employed for the final stage is seen nearest to the die. For the spark-machining operations, the total time was about 6½ hours.

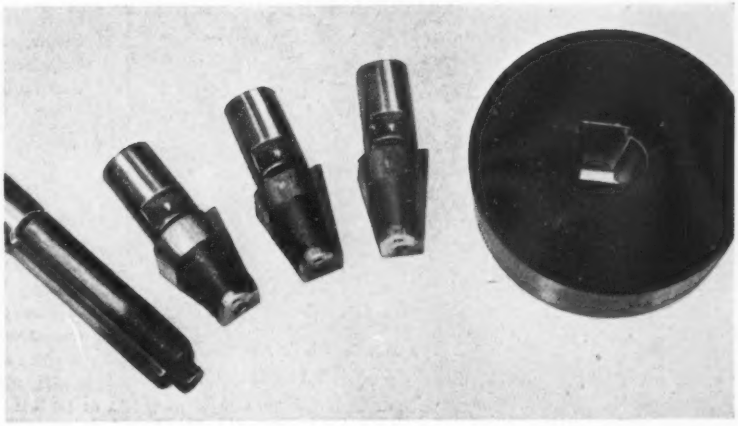


Fig. 7. A Set of Electrodes for Spark Machining on a Drawing Die for Steel Bar, and the Die Produced with them. The Sides of the Die Aperture have an Angle of 8 deg., and Electrodes with Similar Angles are Employed

Two examples of hexagon nut forging dies for ¾ in. A/F nuts are shown in Fig. 8, together with the electrodes employed for machining the cavities. Such a die is prepared by drilling a hole of ½ in. diameter through the billet, and counterboring ¾ in. diameter to the required depth. After it has been hardened, the blank is set-up, with the starting electrode that is seen at the lower right in Fig. 8.

The electrode shown has so far been used to rough-cut the cavities in six dies, and after each operation the eroded portion is machined away. For finish-sizing the die cavity, in which the walls are required to have a taper of 0·018 in. per inch rather than the 0·002 in. per inch normally produced by the process, the central electrode in Fig. 8, with sides machined at the required angle, is employed. Finally, the chamfer at the entry end of the cavity is spark-machined with the electrode at the left. Each of the cavities shown was brought to the finished condition, ready for use, in a spark-machining time of 1¼ hours.

The last example of work carried out with the G.K.N. spark machine is concerned with carbide-

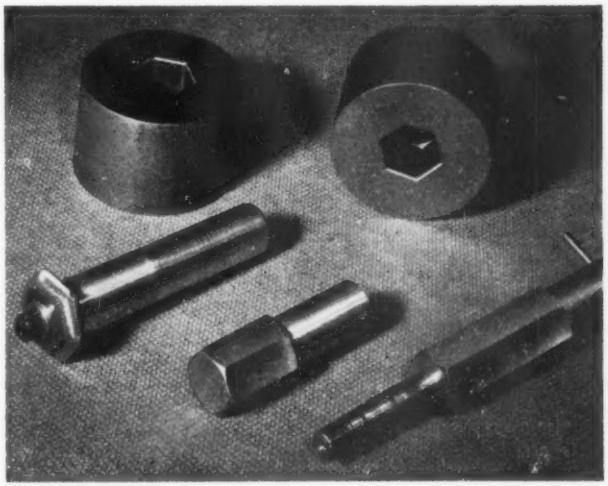


Fig. 8. Two Examples of Dies for Forging Operations on ¾-in. A/F Hexagon Nuts, Spark-machined with the Electrodes Shown. The Electrode on the Right, Employed for Roughing, has so far been used for Six Dies, the Eroded Portion being Machined Away After Each Operation

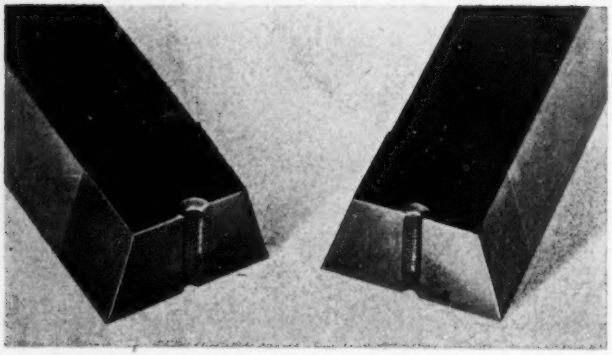


Fig. 9. These Carbide-faced Fingers are Employed in a Nail-making Machine to Grip the Stock while the Head is Upset. Grooves in the End Faces are Produced by Spark Machining

tipped gripping fingers for a nail-making machine, as shown in Fig. 9. Grooves are required in the opposing faces of these fingers, which measure ⅞ in. at their widest point, and in the nail-making machine they are brought together to grip the wire near its end. Material is then upset into a head by the punch on the machine. In the example shown, the grooves in the fingers, in which the wire is held, have circular serrations so that a firmer grip is ensured, and the ends of the grooves are chamfered to provide a cavity in which the head is formed.

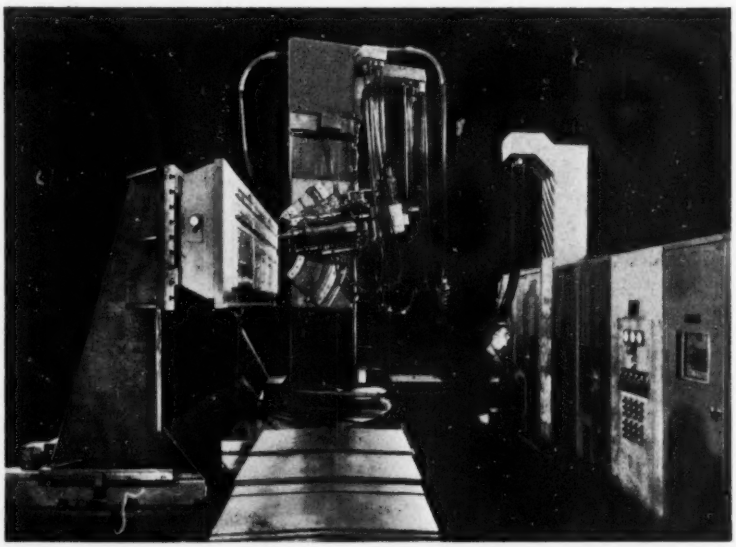
The grooves in these components are produced by placing the faces together with a thin shim between them and to spark-machine a hole with a rod of suitable diameter, the serrations and the chamfer being produced at a separate stage. The alternative method which is preferred, is to machine each groove separately with an electrode held horizontally, the electrode being designed to produce the serrations and chamfers at the same time. Such shallow grooves can rapidly be spark-machined from the solid.

Large G. & L. Variax Tape-controlled Profile Milling Machine

The large-capacity Variax profile milling machine shown in the figure has been built by the Giddings & Lewis Machine Tool Co., Fond du Lac, Wisconsin, U.S.A., for the Lockheed Aircraft Corporation, Burbank, California. Intended for profile milling airframe parts of intricate shapes for the Lockheed F-104 Starfighter, this machine incorporates the Giddings & Lewis Numericord magnetic tape control system, full details of which were given in MACHINERY, 87/151—15/7/55.

The cutter head can be moved in a direction parallel with the spindle axis for controlling the depth of cut, and is arranged to swivel in the vertical plane on a saddle, which, in turn, can be traversed on the column ways. In addition, the column can be traversed on the bedways, and swivelled about a vertical axis.

Rockwell Machine Tool Co., Ltd., Welsh Harp, Edgware Road, London, N.W.2, represent the Giddings & Lewis Machine Tool Co.



Large Giddings & Lewis Variax Tape-controlled Profile Milling Machine

Examples of Fixtures Employed for Barrel-finishing

In addition to supplying a wide variety of barrel-finishing equipment and materials, the Lord Chemical Corporation, York, Pennsylvania, U.S.A., carry out investigations on behalf of customers to determine the best procedures for specific components, and operate fully-equipped plants where contract work is undertaken. Items finished by the process include some of considerable size, such as turbo-jet rotor assemblies weighing as much as 1,000 lb., which are handled with the aid of a hoist. Such items are held in the barrels in fixtures, and the volume of chips employed is sufficient to ensure that they are almost covered, so that only gentle abrasion of the surfaces takes place and damage is avoided. A typical fixture, shown in Fig. 1, has a framework provided with clamping screws, so that it may be fixed inside a barrel of suitable size. At the centre of the framework there is a shaft on which eight pairs of spider arms, joined together at their outer ends, are free to revolve. Threaded holes are provided in the arms to receive eyes for chains, or spring-loaded rubber-covered rods, on which the components to be finished are placed. Up to four chains or rods may be fitted to each pair of arms, so that a maximum of 32 loading positions is available, and there may be one or more components at each position, depending on the size.

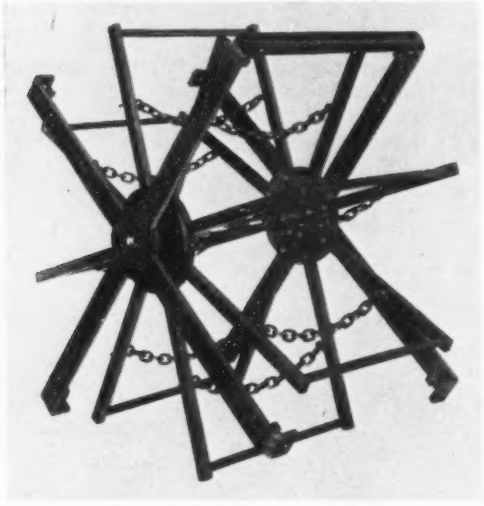


Fig. 1. With this Universal Fixture, which is Fitted Inside the Barrel, Numbers of Components May be Loaded on the Chains, or on Rubber-covered Bars, for Finishing

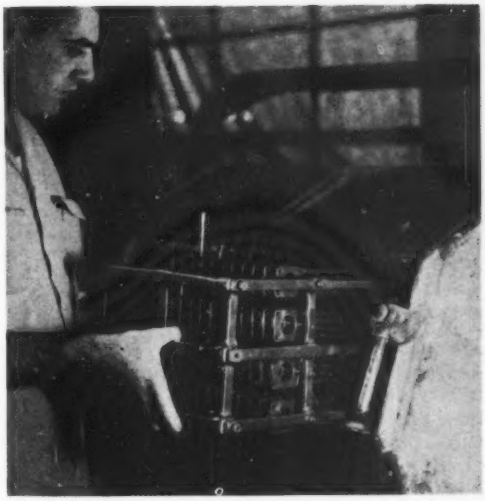


Fig. 2. For Barrel-finishing Stainless Steel Helicopter Straps a Cage-type Fixture is Employed which is Free to Move Inside the Barrel. The Straps are Separated by Spacing Bushes

Components can be unloaded, without emptying the barrel, if desired, by turning the arms on the shaft so that each, in turn, is brought near to the opening. A clamp on one of the arms prevents the components from turning, relative to the barrel, during the finishing cycle. Another fixture, employed for processing stainless-steel helicopter tension-torsion straps, is shown in Fig. 2. In this cage-type fixture, four rows of straps are held, by means of conveniently-placed holes at each end, on bars extending from one side of the cage to the other. Spacing bushes are threaded on the bars during loading, to hold the components apart, and

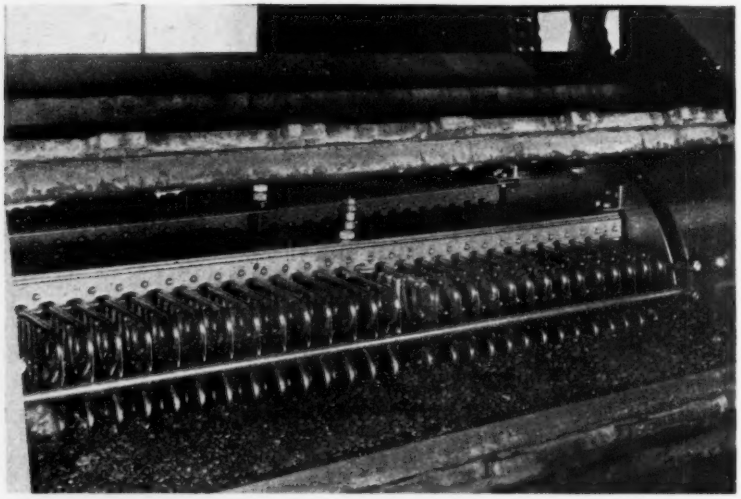


Fig. 3. Stainless Steel Heat Exchanger Plates Measuring 44 by 16¼ in. are Accommodated in Slots in the Fixture in this 72 cu. ft. Capacity Barrel

the fixture is placed loose in the barrel, which is filled to 60 per cent of its capacity. Burrs are removed from these components, and the edges are rounded, during a period of 5 hours, with the barrel rotating at 16 r.p.m., the direction of rotation of the barrel being reversed after half the time has elapsed.

Stainless steel heat exchanger plates for milk pasteurizing machines are finished in the barrel shown in Fig. 3, in which they are held on edge by slots in bars made from angle-section material. At the slots, the bars are reduced in thickness to avoid masking more of the components than is necessary. This barrel has a capacity of 72 cu. ft. and will hold 28 plates, which measure 44 by 16¼ in., and are pressed from 0·038-in. thick sheet material.

For deburring and polishing the surfaces of these plates, the cycle time is 5 hours with the barrel rotating at 16 r.p.m., the direction of rotation being reversed after 2½ hours. A mixed chip-load is employed, with a non-abrasive compound, and the water level is arranged to be below that of the chips.

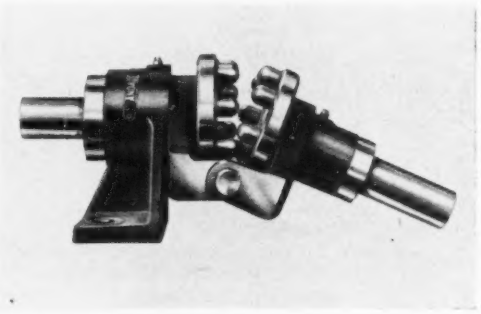
Standage Universal Joints

An example from the Lineta Uni-Joint range of universal joints, introduced by Standage Power Couplings, Ltd., Telscombe Cliffs, Newhaven, Sussex, is shown in the illustration.

Intended for use in connection with the remote operation of stop cocks, valves, and steering gear, these joints are made in five sizes which have driving and driven shafts from ½ to 1½ in. diameter, and will transmit from 150 to 5,000 lb.-in. torque.

The opposing flanged ends of the stub shafts are fitted with equally-spaced pins with dome-shaped ends, which mesh with each other for transmitting the drive. One assembly is pivoted, and can be swung through a maximum angle of 90 deg. from the co-axial position without disengagement of the pins.

With this arrangement, the drive can thus be transmitted when the shafts are set at different angles to each other. The other assembly may be fitted with either a flanged or a right-angle bracket, as shown, for fixing the complete unit in the required position.



An example from the Standage Lineta Uni-Joint Range of Universal Couplings. A Flanged Bracket can be Supplied in Place of the Right-angle Bracket Shown

Rowland Single-ended Horizontal Spindle Surface Grinders

F. E. Rowland & Co., Ltd., Reddish, near Stockport, have recently supplied several single-ended horizontal spindle surface grinders, which incorporate certain basic units of similar design to those employed on their well-known range of duplex machines. Special drum-type work-holding fixtures are built into these machines, which are intended for grinding, on a continuous basis, single end faces on the components, to close limits of accuracy.

Equipped for grinding end faces on small pistons for motor-car brake assemblies, at the rate of 80 per min., the machine shown in Fig. 1 is arranged for fully automatic operation, and is provided with automatic work gauging and wheel dressing equipment. A 20-in. diameter abrasive disc, of the inserted nut type, is mounted on the substantial grinding spindle, which runs in precision pre-loaded ball and roller bearings, and is driven by multiple V-belts from a 7½-h.p. motor mounted on a hinged platform on top of the wheel-head. Guided in precision hand-scraped guideways on the fabricated steel bed, the wheel-head is universally adjustable so that the grinding disc can be set at different angles in relation to the surface of the work.

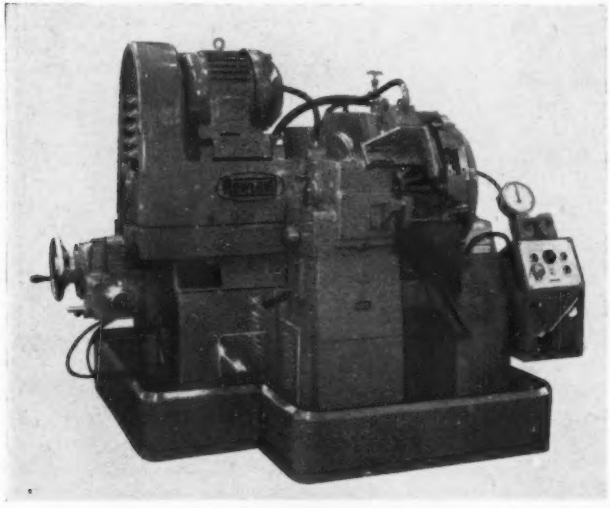


Fig. 1. Rowland Single-ended Horizontal Spindle Surface Grinder for Small Pistons for Motor Car Brake Assemblies

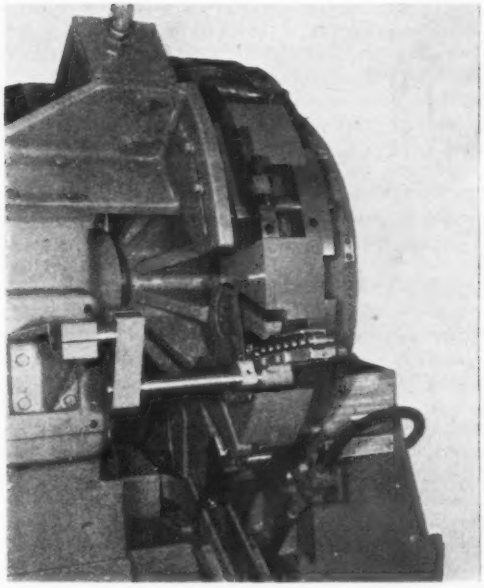


Fig. 2. Close-up View of the Workholding Fixture Employed on the Machine Shown in Fig. 1

Referring to the close-up view, Fig. 2, the work-holding fixture takes the form of a circular carrier with a number of equally-spaced V-blocks at the periphery. It is continuously-driven, at a speed which may be steplessly-varied from approximately 1 to 3 r.p.m., by a ¾-h.p. motor, through a variable-speed belt system and a double-reduction worm gearbox. The workpieces are loaded into an inclined chute down which they roll by gravity to be received, one at a time, by the V-blocks. As the carrier rotates, each part is held in engagement with one end of the V-block by a spring-loaded guide piece, and

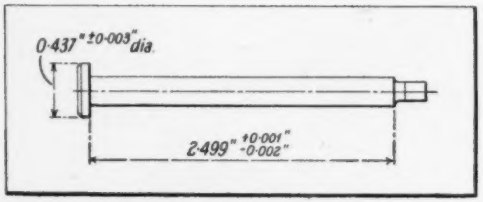


Fig. 3. A Pole-piece which is Ground on the Face of the Head on a Rowland Horizontal Spindle Surface Grinder

it is then clamped by a pivoted arm with a hardened steel contact piece at the outer end, which is swung to the closed position by spring action. Upon completion of the grinding operation, each component is automatically checked for length by the air-operated gauging equipment, and the clamping arm is then swung to the open position by the action of a fixed arcuate plate cam. Finally, the ground part is discharged by gravity on to a second inclined chute.

The use of springs for closing the clamping arms, obviates the risk of damaging the mechanism if a component should be incorrectly loaded. A safety switch is fitted which then stops the carrier before the piece enters the grinding area. All moving parts of the fixture are totally-enclosed and protected from abrasive dust and coolant.

The wheel-head is held in contact with a fixed stop by hydraulic pressure, and may rapidly be moved clear of the fixture, for changing abrasive discs, by operation of a conveniently-placed hydraulic valve. An electro-hydraulic unit, mounted on the left-hand end of the wheel-head slide, as shown in Fig. 1, enables pre-set increments of in-feed, which can be varied steplessly from 0·0001 to 0·0024 in., to be applied to the slide to compensate for wear of the abrasive disc. Adjustments may be made either by depression of a push-button mounted on the control unit at the opposite end of the bed, or automatically, by a signal transmitted by the workpiece gauging equipment. The wheel-head traversing screw is then rotated by the action of a solenoid-controlled hydraulic cylinder and a roller clutch and worm gearing. Coarse and fine adjustments of the wheel-head for setting purposes are obtained by means of separate handwheels.

The tungsten carbide measuring head of the gauging unit is mounted on a slide, which is adjustable for setting, and is connected to a large-diameter dial indicator which gives readings to 0·0005 in. Sensitive electrical contacts incorporated in the indicator head are set so that a signal is transmitted, for adjusting the wheel-head, when the length of the workpieces approaches the upper limit. The resulting movement of the wheel-head then causes the workpieces to be ground slightly above the lower limit for length.

Mounted horizontally at the rear of the substantial wheel guard, the diamond dressing attachment is brought into use automatically, by means of a timer housed in the control unit. The timer can be pre-set so that the period between successive dressing operations can be varied up to 4 hours. The holder for the single-point diamond has micrometer adjustment, and is traversed across the face of the abrasive disc by a hydraulic cylinder, the ram of which is totally enclosed in all positions of its travel. If required, the dressing unit can be brought into use by pressing a push-button. A signal lamp is fitted, which, when illuminated, indicates that the abrasive disc needs to be changed. The wheel guard is of split design, and the upper half can be removed for changing the abrasive disc.

A coolant separator is provided, and a large-capacity suds tray surrounds the base at the level of the shop floor.

A machine of similar design, but arranged for semi-automatic operation, has been built by the company, for face grinding the large-diameter ends of pole-pieces for automatic telephone switchgear,

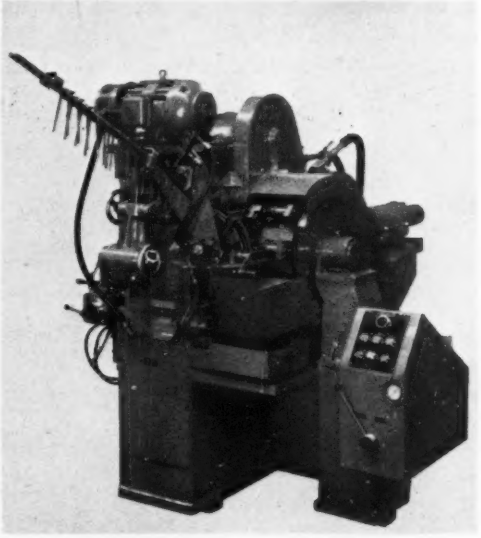


Fig. 4. This Rowland Machine is Designed for Cutting-off Surplus Metal and Face Grinding the Stem Ends of Motor Car Valves

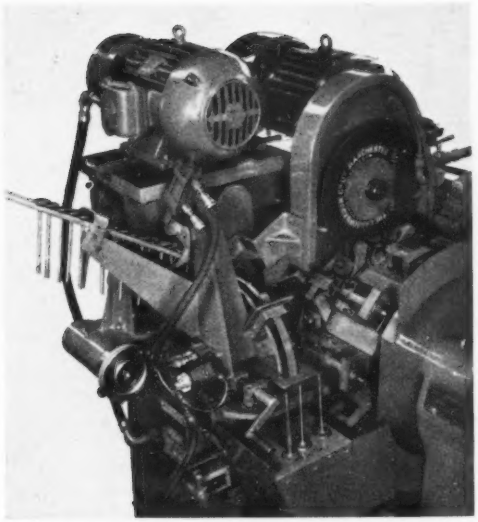


Fig. 5. Close-up of the Machine Seen in Fig. 4

as shown in the line drawing, Fig. 3. In operation, the pole-pieces to be ground are loaded into stepped V-blocks in the continuously-driven work carrier, by way of a gravity feed chute. As the carrier rotates, the shoulder at the small-diameter end of the work is held in contact with the step in the V-block by a spring-loaded guide piece, for endwise location, and the piece is then clamped in readiness for the grinding operation.

The electro-hydraulic unit for adjustment of the wheel-head slide to compensate for wheel wear is arranged for operation by push-button only. A hand-operated wheel dressing attachment fitted with ball-bearing mounted truing cutters is provided, and adjustment of the wheel-head slide, after the dressing operation has been completed, is made by means of the fine feed handwheel. With this machine, pole-pieces are handled at the rate of 30 per min. Approximately 0·012 in. of metal is removed from the face of the component, and a tolerance of 0·001 in. is maintained on the distance from the face to the shoulder.

Two machines of the type shown in Fig. 4 have been supplied to Vauxhall Motors, Ltd., for cutting off surplus metal and face grinding the stem ends of motor car valves. Each machine will handle valves at the rate of 15 per min. Components, in the "as forged" condition, are delivered to the work-holding fixture by an automatic loading unit designed by Vauxhall Motors, Ltd. After each part has been transferred to the fixture, it is located endwise by a spring-loaded guide piece, and then clamped. Lengths from ¼ to ¾ in. are removed from the valve stems by a 12-in. diameter abrasive cutting-off wheel which runs at a speed of 12,500 ft. per min. The wheel spindle is mounted in precision pre-loaded ball bearings and is driven through multiple V-belts by a 5-h.p. motor. Upon completion of the cutting-off operation, continued rotation of the fixture causes the valves to be traversed past a second wheel on which the end faces are ground. Finally, the valves are discharged by gravity into a tray.

A close-up view of the machine, with the guard for the cutting-off wheel removed, is given in Fig. 5. The spindle head for this wheel can be moved in an arc, and, for operation, it is set in its lowest position, to avoid the need for adjustment to compensate for reductions in diameter caused by wheel wear. For changing the cutting-off wheel, the spindle head is swung upwards clear of the working area by means of a screw. Longitudinal adjustment is provided for the wheel-head, for setting the face-grinding allowance.

The machine is arranged for wet-grinding, and a paper-type coolant filter is mounted on the floor at the rear of the base. Special provision is made for handling the large quantities of sludge resulting from the grinding operation, and there is a detachable basket for the reception of the pieces which are cut off from the valve stems.

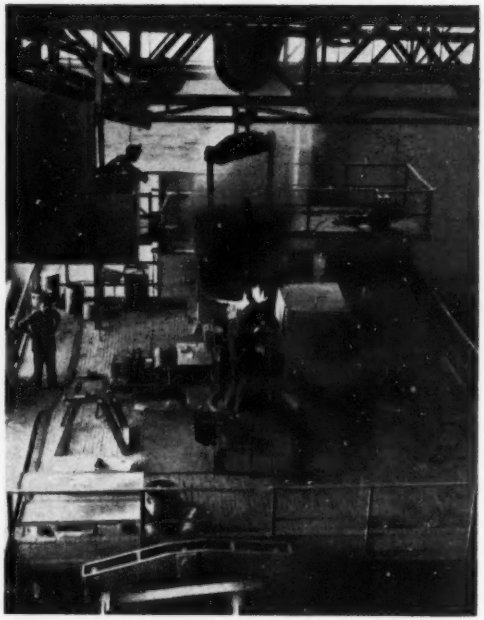
SHEET BERYLLIUM FOR USE IN GUIDED WEAPONS.—It is reported that the Brush Beryllium Co., Cleveland, Ohio, U.S.A., have recently received a contract to develop manufacturing techniques for the production of sheet beryllium for application to weapon systems. This contract calls for beryllium sheet to be rolled from pressed-powder slabs, and the finished sheets are to be in three width ranges, namely, 12 to 18, 18 to 24, and 24 to 30 in. The thicknesses of the sheet in the three ranges will be 0·020, 0·040, and 0·060 in., respectively.

Beryllium offers the advantage of being three times as strong as steel, whilst its weight is only two-thirds that of aluminium. Furthermore, it retains its physical properties at elevated temperatures within the range of 1,000 to 1,200 deg. F. Mention is made of the fact that beryllium-based alloys are now being developed which can be used at temperatures as high as 1,500 deg. F. It is interesting to note that the weight of a fighter constructed entirely from beryllium, and designed to operate at a speed equal to 2½-times that of sound, would be 16,000 lb. less than the same machine constructed from steel.

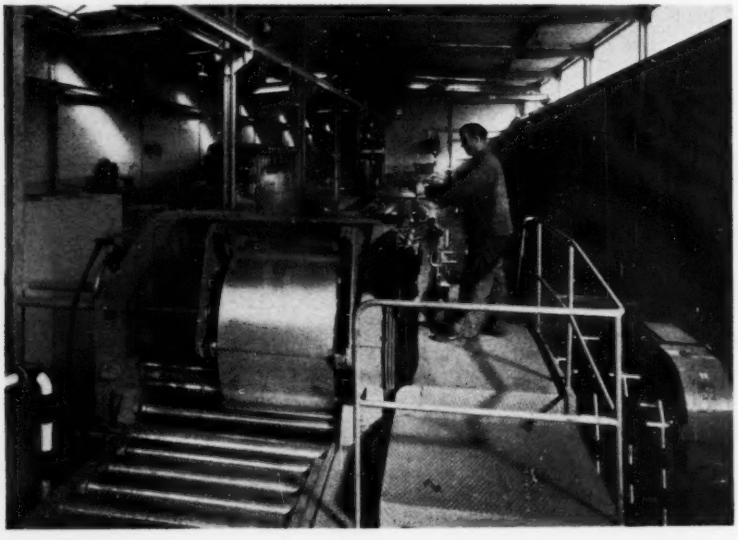
A Modern Swedish Steelworks

Situated at Nybybruk, on the outskirts of Eskilstuna, Sweden, the firm of Nyby Bruks A-B. employs 1,100 people, and is mainly concerned with the production of stainless steel ingots, sheet, bar, and tube. The annual production of stainless steel ingots is 22,000 tons. The equipment of the melting shop comprises two electric arc furnaces, with capacities of 14 and 16 tons, and a high-frequency induction furnace with two crucibles, each with a capacity of 5 tons. In the same shop, there is a continuous casting machine which produces round or square billets, and slabs.

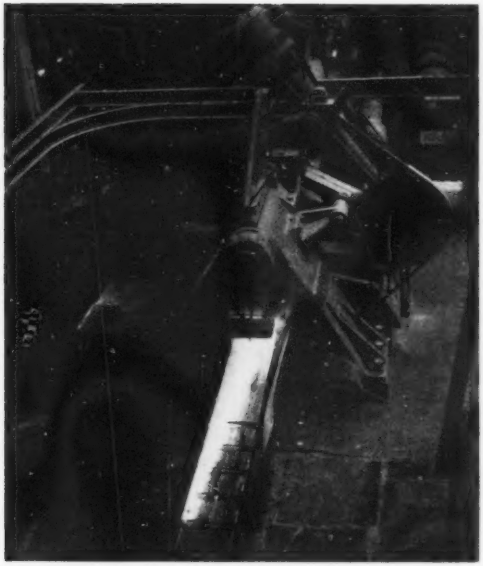
Stainless steel tubes and sections are produced on a 1,700-ton Fielding extrusion press, by the Ugine Sejournet process, and stainless steel sheet, up to 55 in. wide, is made on a semi-automatic cold rolling plant. Other departments of the works include a hot rolling mill; a bar rolling mill; a tube drawing department; an investment casting foundry; and extensive workshops, in which the continuous casting machines were built. There is also a welding shop, for fabricated work, and for the production of large-diameter stainless steel tubes. Some aspects of the company's plant and activities are shown in the accompanying illustrations.



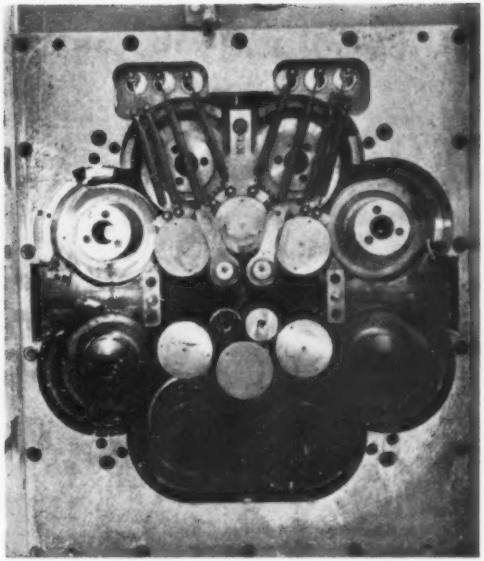
A view of the upper platform of the continuous casting machine, showing pouring in progress. Built under licence from an American company, the machine will cast 3-in. to 8-in. round or square billets, or 2-in. by 14-in. slabs. The firm have supplied similar machines to companies in England and Yugoslavia.



At the head of the stainless steel cold rolling line, this Tibo (Swedish) machine is employed to weld the stock, which is 0·138 in. to 0·158 in. thick, into continuous strips approximately 390 ft. long. Welding is performed by the argon arc process, for which equipment by AGA and ASEA is incorporated

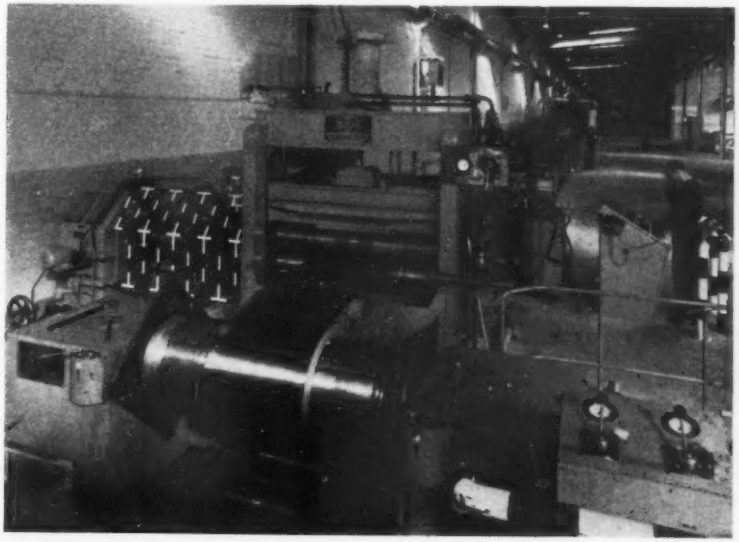


The 1,700-ton Fielding extrusion press, employed for producing stainless steel tubes and sections by the Ugine Sejournet process. Tubes range from 1¼-in. to 5-in. diameter, with a minimum wall-thickness of 0·12 in. This machine, it may be noted, was originally used for non-ferrous extrusions. Stainless tubes and sections are de-scaled by the Hocker process (Hocker Electrochemical Corp., Niagara Falls, U.S.A.)



In this view of the Sendzimir cold rolling mill, which was built by Demag, the arrangement of the two main rolls, each with nine back-up rolls, is clearly shown. The small size of the main rolls will be noted. On this mill, the welded and heat-treated strip is reduced to a thickness of 0·02 to 0·08 in. All functions including the speed and the setting of the rolls are controlled from a console.

After it has been welded, the coiled material is fed through the uncoiling machine here shown, and thence continuously through an annealing furnace, a shot-blasting machine, and pickling baths, to a coiling machine. As may be observed, the operator at the control console is in telephone contact with other stations in the line



Fosmatic Automatic Jig Borer with I.B.M. Punched-card Control System

Built by the Fosdick Machine Tool Co., Cincinnati, Ohio, U.S.A., the Fosmatic No. 54 jig borer, shown in Fig. 1, is installed in the Endicott, New York, plant of the International Business Machines Corporation, and incorporates an automatic punched-card control system developed by the latter company.

With this system, positioning of the work table in both directions, selection of spindle speeds and feeds, changing of cutting tools for different operations, adjustment of the spindle head for height, and control of the depth of the bored holes, are entirely automatic. A separate system is provided for automatically disengaging the rapid power traverse and engaging the cutting feed during the downward travel of the spindle. The machine is employed for performing 30 operations on 16- by 18-in. side frames for business machines, and the centre distance between any two holes is held accurate within 0·0004 in.

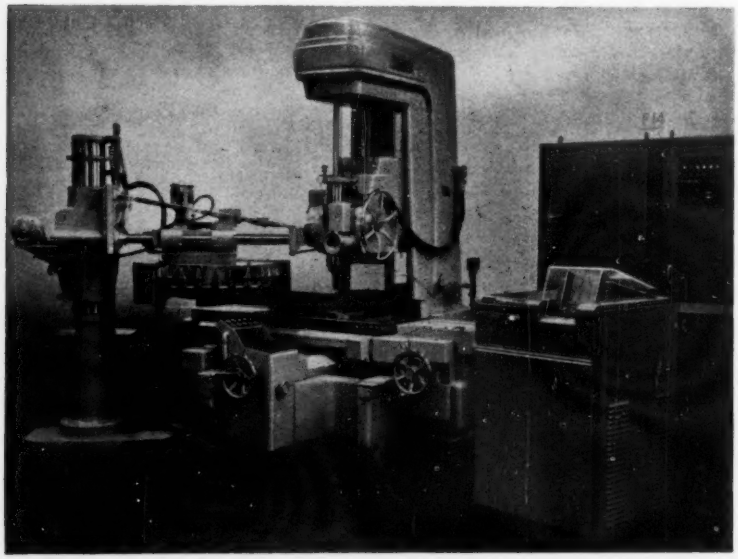


Fig. 1. Fosmatic No. 54 Automatic Jig Borer with I.B.M. Punched-card Control. Pre-set Cutting Tools are Held in the Indexing Carrier Seen at the Left and are Automatically Mounted in the Spindle as Required

Information concerning all machine motions for one hole is provided on a single punched-card, a number of which, covering the entire operating cycle, is loaded into a card reader mounted on the floor at the right-hand end of the jig borer. Positioning of the table and saddle is obtained to an accuracy of ±0·0001 in. by means of end measuring bars, which are selected by motor-driven drum dials. Traversing of the table and saddle serves to "stack" the measuring bars and causes them to operate a switching system. When the selected settings have been obtained, the traversing screws are reversed to release end thrust, and the table and saddle are then clamped.

Sixteen spindle speeds ranging from 30 to 1,800 r.p.m., and 8 feeds, from 0·0005 to 0·01 in. per revolution, are obtainable, and are brought into use, as required, by electro-magnetic clutches.

Cutting tools for different operations are pre-set in holders with taper shanks, and are stored in readiness for use in a 30-station indexing carrier, which can be moved towards and away from the spindle on horizontal cylindrical guide bars supported by a separate floor-mounted column. At the beginning of a fresh machining operation, the carrier is moved towards the spindle and indexed for selecting the required cutting tool. With the fresh tool positioned beneath the spindle, the holder is gripped by a pair of jaws attached to the spindle head, which engage with a hexagonal portion at the lower end of the shank, as may be seen in the close-up view, Fig. 2. Next, the carrier is returned to its original position, and the spindle

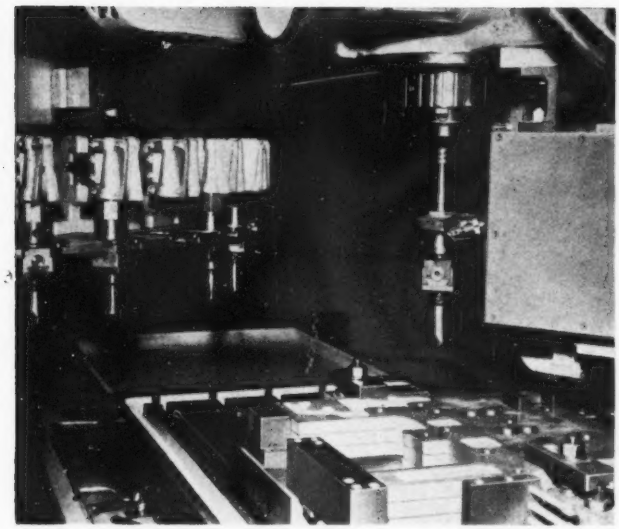


Fig. 2. In this Close-up View One Cutting Tool is Shown in Position in the Gripper Jaws in Readiness for Attachment to the Spindle, and Others can be Seen in the Indexing Carrier

is then rotated slowly and is simultaneously moved downwards to engage with the threaded upper end of the shank. When the toolholder has been tightened to a pre-determined torque, the gripper jaws are released and then swung clear so that machining can proceed. This sequence of operations can be performed while other settings are being made. At the end of the upward travel of the spindle, upon completion of the machining operation, the sequence is reversed for releasing the toolholder and returning it to the carrier.

As soon as a fresh cutting tool has been secured to the spindle and the gripper jaws have been brought clear, the spindle is moved downwards under rapid power traverse. During this movement, the cutting tool passes through a light beam which is directed horizontally between a lamp and a photo-electric cell attached to the spindle head as indicated in the diagram, Fig. 3. Interruption of the light beam causes an electronic counter to be energized, and rapid traverse of the spindle then continues for a pre-set distance. When the cutting tool is positioned approximately $\frac{1}{16}$ in. above the work surface, the cutting feed is automatically engaged by the action of the counter.

As soon as the cutter makes contact with the work, the counter is again energized by a piezo-electric vibration pick-up crystal attached to the work-holding fixture. Signals are then transmitted by the counter, for each 0·001 in. of down feed, to a shaft digitizer, which is connected to the feed drive and controls the cutting depth in accordance with the information on the punched cards. At the end of the boring operation, the spindle is automatically stopped simultaneously with the interruption of down feed, and is then returned to the top of its travel. It is stated that, with this arrangement, bored holes are held to an accuracy of 0·002 in. for depth.

Automatic adjustment of the spindle head enables a number of holes to be bored, on an entirely automatic cycle, in surfaces of different heights on stepped parts. Since the photo-electric unit for controlling the rapid power traverse of the spindle is mounted on the head, the distance between the cutting tool and the work at which the feed is engaged is maintained at a constant value for different settings of the head.

Since all the motions of the machine are effected automatically, the risk of producing spoiled work due to errors on the part of an operator is entirely eliminated. It is stated that only a short period is required for setting-up, and the machine can be used to advantage for handling single components and small- and medium-size batches. The Fosmatic No. 54 jig borer is also available with

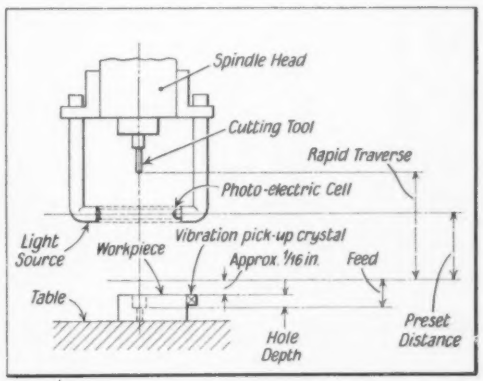


Fig. 3. Diagram Indicating the Photo-electric Unit, and Vibration Pick-up Crystal, for Controlling the Rapid Power Traverse and Feed Motions of the Spindle During the Operating Cycle of the Fosmatic Machine

a punched-tape control system, and a machine of this type, with provision for automatic positioning of the table and saddle only, was described in MACHINERY, 92/496—28/2/58.

Gaston E. Marbaix, Ltd., Devonshire House, Vicarage Crescent, London, S.W.11, are the agents in this country for the Fosdick Machine Tool Co.

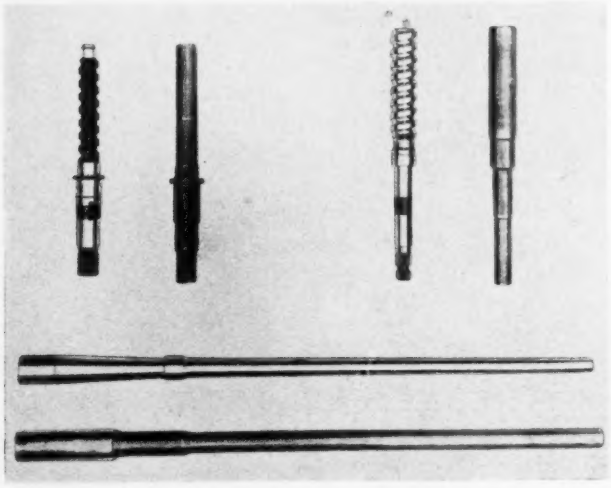
The Republic Die-Form Process

A new method for cold reducing diameters of hot-rolled steel bars has recently been introduced by the Bolt & Chain Division of the Republic Steel Corporation, 1,970 Carter Road, Cleveland, Ohio, U.S.A. By this method, it is claimed, very substantial savings of raw material can be obtained in the manufacture of stepped components from plain carbon, alloy and stainless steels. The process can be employed, at present, for the production of parts up to 42 in. long by 2 in. diameter, and examples are seen in the illustration. The blanks produced by the Die-Form process are here shown, together with two finish-machined motor vehicle steering worms, and a rifle barrel. It will be evident from these examples how closely the blanks are shaped to the required finished forms, so that the minimum of metal need be removed by machining.

With the Die-Form process, dies are pushed over a cut off blank, if necessary from opposite ends, for the required distance, and then stripped off. One die is required for each diameter step, so that a multi-diameter blank is produced in a series of operations. Much greater reductions are possible with this method than by cold drawing, since the load required to pull a bar through a die may easily exceed the tensile strength of the material with the result that the bar is broken.

Apart from motor-car components, for which it was developed during a period of steel shortage, the process has been applied to the production of shafts for farm equipment, domestic appliances, and electric motors, for example. It may be noted that by Die-Forming the rifle barrel blank, the amount of steel required was reduced by 45 per cent.

In addition to saving material, the process enables machining times to be reduced, since there is less metal to be removed, so that more parts can be machined with existing plant. Moreover, there is less weight to be handled, both of raw material and scrap. Other advantages are that the physical properties of the steel are often improved to a greater extent than by cold drawing, machinability is improved, and the need for using resulphurized steel is sometimes avoided. It is stated that 10 (short) tons of blanks is the minimum quantity for which the process is normally economical. Diameters can be held to within 0·005 in., so that chucking is facilitated, and lengths up to a shoulder, within 0·0625 in. In some instances, straightness can also be maintained within a total tolerance of 0·005 in.



Examples of Blanks Produced by the Republic Die-form Process and the Finish-machined Components

EASY-UNWIND MASKING TAPE.—Minnesota Mining & Manufacturing Co., Ltd., 3 M House, Wigmore Street, London, W.1, inform us that their Scotch Boy masking tape is now supplied with "easy-unwind" properties. It is stated that, as a result of a new process, the non-sticky side of the tape, actually repels the adhesive.

Consequently, the tape comes off the roll without resistance, and no stretching of the crepe backing paper occurs. The stretching properties are thus preserved, so that the tape can be applied more effectively for the masking of contours, and on uneven surfaces.

Owing to the thinness of the tape, sharp edges are provided, and it has moisture-resistant properties to prevent creep-under during wet sanding.

Two-head Belt Grinder for Stator Components

A 30 per cent increase in output of de-flashed and surface-ground stator components for the 407 electric accounting machine has been obtained, following the installation of a double-head belt grinder at the Endicott, N.Y., U.S.A., plant, of International Business Machines Corporation. Of the conveyor type, this grinder is equipped with a gravity feed hopper.

The purpose of belt grinding is to remove excess flash following a phenolic moulding operation, and to reduce the beryllium-copper parts to a uniform thickness of 0·0508 in. ±0·0016 in. Stator vanes are blanked from strip stock which is cadmium-coated to reduce die wear. The 3- by 4-in. vanes are then stripped in acid dip, heat-treated to 45-48 Rockwell C., and bright-dipped. Thermosetting phenolic material is baked into 16 openings in each plate. This phenolic material serves as insulation between the electrical contact fingers. After the resulting flash has been removed by belt grinding, linen-laminated material is heat-cemented to both sides, and the edges are trimmed to size. Each of the two stators used in the 407 accounting machine is made up of 80 stator vanes.

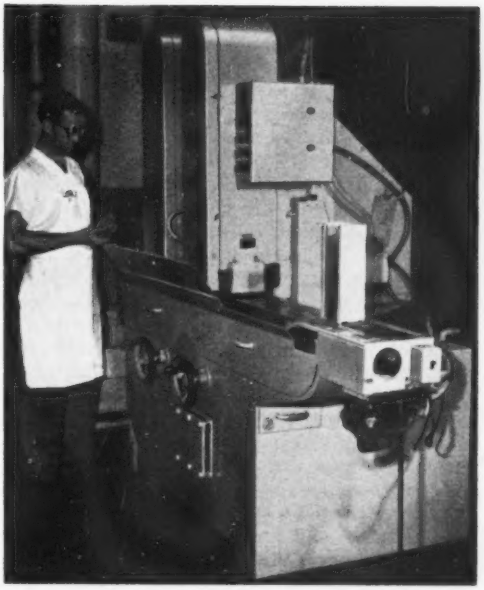


Fig. 1. This 2-head Belt Grinder, Equipped with 36- and 50-grit Silicon-carbide Belts, Removes Phenolic Flash from Beryllium Copper Stator Components and Grinds the Surfaces

On a two-head belt grinder (shown in Fig. 1), which was built by Engelburg Huller Co., Syracuse, N.Y., these parts are ground on both sides at the rate of 2,600 per 8-hour day. The workpieces are loaded in a special magazine fixture, seen in Fig. 2, which is equipped with a speed reducer so that the feed rate can be synchronized with the speed of the conveyor belt. An oscillating feed-bar, which is slightly thinner than the stator components, is moved in a grooved channel to feed one part

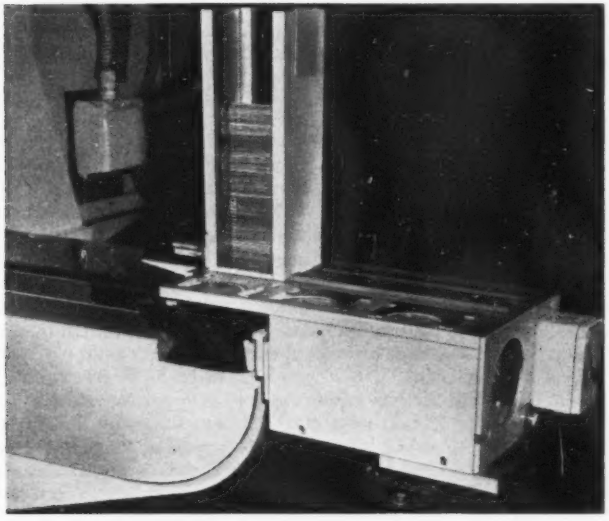


Fig. 2. The Speed of the Motor-driven Sliding Feed-bar for the Magazine Loading can be Varied to Synchronize with the Speed of the Conveyor Belt

from the bottom of the stack on to the conveyor belt at each forward motion.

Speed of the 70-durometer rubber conveyor belt, which is 7 in. wide by 144 in. long, is set at 8 ft. per min. for this application. The parts are carried automatically under both grinding heads, ejected into trays, and then returned for similar operations on the reverse side. On the first grinding head, a 36-grit silicon-carbide abrasive belt is used in conjunction with a steel contact wheel, and on the second head, a 50-grit belt with a 70-durometer rubber contact wheel. These belts enable each side of the part to be finished in a single pass, and the resulting grain pattern has improved the quality of the bond when the linen laminates are pressed on to the finished surfaces.

The hopper capacity is 150 parts for the first pass and 200 for the second, and after loading the hopper, the machine operator is free to make visual inspection and micrometer spot checks.

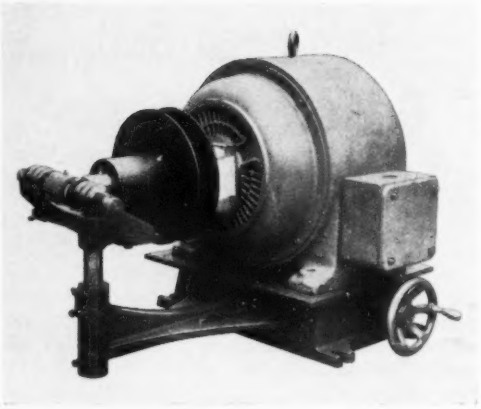
Micrometer control wheels provide for independent adjustment of the grinding heads on the machine, and hold-down rolls, mounted on either side of each grinding head, ensure positive and uniform feed of parts under the contact wheels. Each abrasive belt is 6 in. wide by 80 in. long, and is driven at 5,500 surface ft. per min. These belts can be changed in less than 2 min.

A self-contained coolant system applies the coolant (water with a rust inhibitor) directly to the work area, and also sprays it forcibly across the full width of the abrasive belts, to prevent loading, so that a sharp cutting surface is maintained. On average, 850 parts are processed per belt.

Druce-Elliott Variable-speed Drive

Shown in the figure is the latest Druce-Elliott variable-speed drive unit, made by Industrial Drives, Ltd., 44 Uxbridge Road, Ealing, London, W.5. With this unit, speed variations are obtained by an adjustable V-belt pulley, the inner flange of which is fixed to the shaft of an electric motor, and has an extension sleeve on which the outer flange can slide for increasing or decreasing the effective diameter. For making adjustments, a slide which carries the motor is traversed on guideways in the base by a handwheel and screw.

The outer flange of the pulley is connected to a swivel T-piece which can slide on a horizontal cylindrical guide bar secured to a bracket. Of 2-piece construction, this bracket is attached to the upper end of a cylindrical column, which is fastened to an arm fixed to the base. The guide bar is inclined at an angle to the driving shaft



Druce-Elliott Variable-speed Drive Unit

of the motor, and, because it is connected to the outer flange of the pulley by the T-piece, the flange is caused to move axially when the slide is traversed on the base. Since the guideways in the base are set at an angle in relation to the motor shaft, the entire pulley assembly moves in a direction parallel with its axis when adjustments are being made, so that alignment of the belt is maintained.

Fine screw adjustment is provided for swivelling the upper part of the bracket on the lower portion, so that the guide bar can be set at different angles in relation to the motor shaft. The outer flange of the pulley rotates in relation to the T-piece on ball bearings, and the guide bar is fitted with bellows-type guards. The unit can be supplied for use with motors from ½ to 15 h.p., and the guide bar can be adjusted vertically to suit the centre height of the motor driving shaft.

NILDISENE CUTTING OIL, which has been introduced by The W. Blackwell Oil Co., Ltd., Victoria Oil Works, Aston, Birmingham, 6, is intended to be mixed with water in the proportion of 1:15 for general machining operations on ferrous metals, and is claimed to offer various advantages. Stronger or weaker solutions may be suitable for other applications. It is stated that the solution obtained has a clear brown appearance and does not obscure the work, that in proportions of 1:30 or stronger, it does not cause rusting of work or machines; that it possesses good cooling properties and high film strength; and that it enables long tool life and a good surface finish on the workpiece to be obtained.

Instruments, Electronics, and Automation Exhibition

More than 250 companies from this country and 100 from overseas will be taking part in this year's Instruments, Electronics and Automation Exhibition, which will be held in the Grand Hall, Olympia, London, from April 16 to 25. A conference will be held concurrently with the Exhibition, at which papers on a variety of subjects will be presented by speakers who are specialists in their fields. Of the wide range of products which will be shown, attention is drawn in this article to some items likely to be of particular interest to readers of MACHINERY.

A new product which will be shown by E.M.I. Electronics, Ltd., Hayes, Middx., is the electronically-controlled undercutting machine for armatures of fractional horse-power motors illustrated in Fig. 1. The armature is held by a quick-release collet, and is automatically indexed so that each slot is presented, in turn, to the cutter. This motion, and the actual cutting cycle, are controlled by a photo-electric servo system, and a counter is incorporated for automatically stopping the machine when a pre-determined number of slots has been cut. Slots can be cut at a rate of 1 per sec., and are held to an accuracy of $\pm 0{\cdot}0002$ in. for spacing. Since the operating cycle is entirely automatic, one operator can tend several undercutting machines.

Also of interest will be a working model of an automatic trolley guidance system which has recently been developed by the company. With this system, an electric current is passed through a cable laid either above or below floor level on the route over which the trolley is passed. The resulting magnetic field is detected by two coils, which are mounted at a short distance apart on the front of the trolley and form part of a closed servo loop for controlling the steering gear. As soon as the trolley deviates from the predetermined route, the unbalanced current is applied to the sensing coils, and the servo system is brought into operation.

Several trolleys may be operated independently over the same route, and they can be started and stopped from one or more remote control points. Provision is made for automatically selecting branch routes, and for automatically stopping the trolley in the event of obstruction of the route or failure of the guidance system. The system can readily be installed at low cost, on a temporary basis if required, and since the trolleys are remotely controlled they can be passed through areas, at nuclear energy establishments for instance, which people must not enter.

Available in bench- and floor-mounting designs, the firm's dynamic balancing machines, which are to be shown, will handle cylindrical parts up to 24 in. diameter, with weights from 1 oz. to 150 lb. Examples of the company's stroboscopes will include the type 3D for checking speeds from 120 to 6,000 r.p.m., the type 4A for speeds from 250 to 1,500 r.p.m., and the type 4C for speeds from 300 to 6,000 r.p.m. In addition, a new type 6 stroboscope will be exhibited. A unit known as the Multistrobe is intended for use in conjunction with four stroboscope lamps for checking speeds from 120 to 9,000 r.p.m., and provides for the illumination of either one large area or several small areas

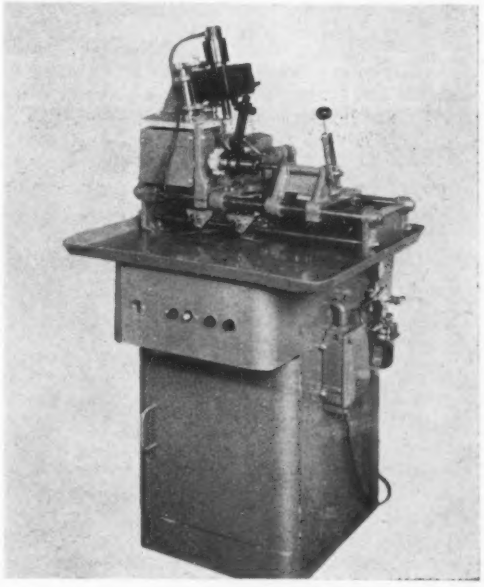


Fig. 1. E.M.I. Electronically-controlled Undercutting Machine for Armatures

of the work. The type 1A tachometer may be used in conjunction with several forms of transducer heads which will produce electrical signals in accordance with mechanical motions. It will handle signals at rates ranging from 40 to 4,000 per sec., and the count is displayed on four dekatron valves for pre-set periods of 1, 2 or 4 sec. Another tachometer, designated type 2, has provision for operating a pen recorder.

Other exhibits will include a vibration generator, an armature tester, a monitor for checking workers and their clothing for radio-active contamination, industrial television equipment, oscilloscopes and the E.M.I.-LogElectronic photographic printer.

Fielden Electronics, Ltd., Wythenshawe, Manchester, will display their new Tektor Major and Tektor Minor industrial level controllers, which are intended to replace the Tektor type J unit. Other exhibits will include the Tektor JF3 flame-proof level controller, and the Aquatrol conductive level controller, the relay of which may be arranged to operate a visual or aural warning system as well as a pump, for instance. The Telstor LF3 continuous level indicator enables the levels of most liquids and free-flowing materials to be checked, and permits the position of the interface between two immiscible liquids in a sealed container to be continuously indicated. Examples from the company's range of process control instruments, their Servograph recorder, and an automatic 50-point temperature scanner with a 36-in. diameter scale will also be on view.

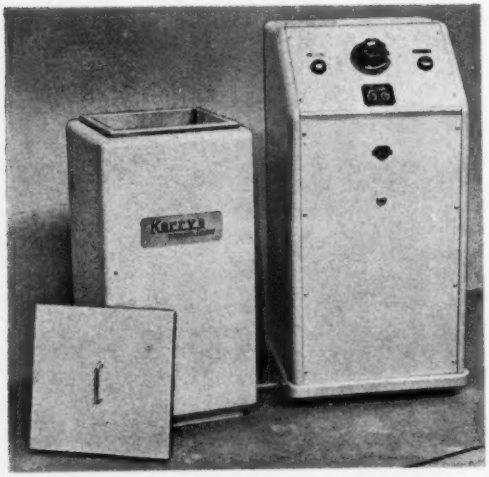


Fig. 2. Kerry Type SHD.1 Ultrasonic Cleaning Equipment

The latest automatic co-ordinate positioning equipment for machine tools, made by Ekco Electronics, Ltd., Southend-on-Sea, Essex, will be demonstrated in conjunction with a new punched-card information-storage system. As was mentioned in MACHINERY, 92/556—7/3/58, the basic equipment incorporates two traverse units, which can be mounted on the compound work table of an existing machine after the handwheels have been removed, for driving the feed screws. It is stated that each traverse unit will position a screw within $\pm 1/500$ part of a single turn, over a traverse movement of 100 in. With a perfect screw of 10 t.p.i. this performance represents 0·0002 in. of linear movement of the table. Since each traverse unit is intended for controlling the rotation of a screw or shaft, the equipment can also be used for obtaining, automatically, accurate settings of rotary tables.

The display will also include examples from the company's range of nucleonic gauging equipment for checking the thicknesses of strip materials and coatings. These items will include a new gauge in which an alpha radio-active source is employed in conjunction with a scintillation counter, and provision is made for automatic calibration. A recently-introduced Bremsstrahlung (low-energy X-ray) gauging unit enables brass, copper, or steel strip up to 0·4 in. thick to be checked. Another recent development is a type N565A temperature-compensated measuring head for nucleonic gauging equipment, which is particularly intended for use when gauging of thin materials. For measuring thicknesses when access can be gained to only one side of the work, there will be a new type N563 gamma back-scatter gauge, which incorporates transistors and printed circuits, and can be supplied for operation from a battery or a mains supply.

Attention may also be drawn to the company's test set for measuring the rate of wear of components such as pistons for internal combustion engines, by the use of radio-active tracers. The part to be tested is first made radio-active and then assembled in the engine. Rate of wear is then measured, while the engine is running, by counting the radio-active particles in the lubricating oil.

Kerry's (Ultrasonics), Ltd., Tonbridge Road, Harold Hill, Romford, Essex, will exhibit examples of the ultrasonic cleaning and machining equipment which they build in conjunction with Mullard, Ltd. A new product is the type SHD.1, high-frequency, ultrasonic cleaning equipment illustrated in Fig. 2, which is destined for installation in the works of a company engaged in the produc-

tion of artificial fibre yarn, for cleaning spinnerettes. Of compact design, the equipment has an operating frequency of 1 megacycle with a peak pulsed output rating of 2 kW., and the cleaning tank measures 13 by 13 by 14 in. It is intended for removing fine particles of contaminants from intricate parts, perchlorethylene being employed as the cleaning agent. Low-frequency cleaning equipment, for use with perchlorethylene or aqueous-based solutions, can also be supplied.

Attention may be drawn to a prototype ultrasonic cleaning tank which incorporates multi-bank transducers and the company's patent Pusatron system, which enables generators of medium output rating to be employed with equipment for cleaning work-pieces with large surface areas.

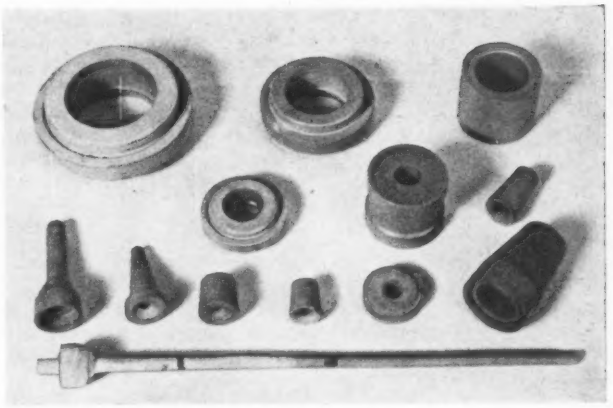


Fig. 3. Some Examples of Components Made from Sintox Ceramic Material

Also of interest will be a patented prototype ultrasonic tapping machine which has recently been developed for cutting screw threads, on a production basis, in hard and brittle materials such as tungsten carbide and ceramics. The cutting tool is mounted at right-angles to the stub at a point of maximum vibrational activity, and it has been found that in this way a torsional effect is imparted to it. Reference to development work undertaken by the company in connection with the cutting of screw threads by ultrasonic means was made in MACHINERY, 91/1443—20/12/57. Another exhibit will be the Kerry Sonorode-2 kW. ultrasonic drilling machine. Ultrasonic equipment made by Mullard, Ltd., will be represented on the same stand by a low-power bench-mounted drilling machine, a 20-kilocycle bench cleaning unit, a new 40-kilocycle twin-beaker cleaning unit, and soldering equipment.

A recently-introduced magnetic powder clutch will be included among the exhibits of Smiths Industrial Instruments, Ltd., Chronos Works, North Circular Road, London, N.W.2. A working exhibit, in the form of a reversing drive unit, will incorporate two clutches which enable a torque of 5·4 lb.-ft. to be transmitted at a speed of 350 r.p.m., and permit up to 6,000 reversals per hour to be obtained.

Other items on view will include a new tape position indicator for use in conjunction with wire or tape recording machines, and the company's calibrated relay which is intended for precise control of speed, voltage, or current. In addition, hand, magnetic and electric tachometers, service counters, Petro-Flex flexible tubing, and oil and fuel pressure gauges, will be exhibited by this firm.

A type FA27A induction heater, which will be shown by British Thomson-Houston Co., Ltd., Rugby, has a rating of 25 kW., for continuous operation, and an output frequency of 500 kilocycles. Another exhibit will be concerned with the B.T.H. Emotrol system for steplessly-variable speed control of electric motors. This equipment is available in two forms, in one of which the electronic valve arrangement serves essentially as a power rectifier, and feeds current to the armature and field of a D.C. motor. With the second arrangement, the electronic equipment provides for regulation of a machine, to alter its speed or other characteristics, through the medium of a Ward-Leonard system. Emotrol units are available for the control of motors from ½ to 600 h.p.

A type FV 29 voltage regulator for generators with ratings up to 5,000 kVA., and the company's Portavox telephone system for use in mines, will also be shown. The type TRP2 infra-red radiation pyrometer comprises a viewing head and control unit of compact design which incorporates transistor circuits. This pyrometer enables readings to be taken from surfaces as small as 0·4 in. diameter. The B.T.H. electronic tracer control equipment for machine tools, which was described in MACHINERY, 86/491—4/3/55, and the automatic positioning system for slides and tables (MACHINERY, 87/262—29/7/55), will also be exhibited. Other items will include the company's Clearcall industrial communication equipment, vibration measuring equipment, leak detectors, frequency meters, an infra-red relay for flame control.

control equipment for resistance welders, photo-electric cells and electronic timers, valves and semi-conductors, and a 16-mm. sound film projector.

The products to be displayed by Lodge Plugs, Ltd., Rugby, have been selected to indicate some of the numerous applications of their Sintox industrial ceramic material which has exceptional hardness, high thermal conductivity, good electrical and mechanical properties at high temperatures, and high resistance to abrasion and chemical attack. Facilities are available for grinding the material, so that components can be made to a high degree of dimensional accuracy. It is claimed to be particularly suitable for the production of valve envelopes, metal/ceramic vacuum seals, spacers, support pieces, coil formers, and terminal blocks, for example. Tool bits in Sintox ceramic for metal-cutting operations are also available, and are distributed by English Steel Corporation, Ltd., River Don Works, Sheffield, 9.

Some examples of components made from this material are shown in Fig. 3. High tension and high energy industrial ignition equipment, for use in oil-fired installations and gas turbines, will also be shown.

Stroboscopic examinations of assemblies likely to be subjected to vibration for non-destructive testing, which represents a new application of X-rays, will be demonstrated by Philips Electrical, Ltd., Century House, Shaftesbury Avenue, London, W.C.2. A new range of equipment for nuclear research purposes will be shown, including a pre-amplifier, an electronic timer, and a single-channel analyser. Reference may also be made to a new strain gauge for the measurement of deformation of concrete, and a high-impedance millivolt recorder. Other exhibits will include a gas refrigeration machine for producing liquid air or nitrogen, for example, mercury vapour rectifying equipment, ignitron tubes, voltage stabilizers, and variable transformers and battery chargers.

Fig. 4. Isotope Developments Type 656 Gamma Switch

The principal exhibits on the stand of Crompton Parkinson, Ltd., Crompton House, Aldwych, London, W.C.2, will comprise items from a new range of circular-scale instruments, including single- and multi-range ammeters, volt-meters, and watt-meters, as well as frequency, power factor, and speed indicators. Also on view will be the "universal indicator" scale arrangement, which enables a wide range of voltage and current measurements to be made with a single instrument using standard shunt and series resistance bobbins. A working exhibit will demonstrate features of the company's electric tachometer, which, when used with a 3-phase generator, enables very slow speeds to be indicated without needle flicker.

The display will also include tong test portable ammeters and a representative selection of instruments for industrial, marine, and educational purposes.

Photo-electric and electronic equipment for a variety of industrial applications will be exhibited by Radiovisor Parent, Ltd., Stanhope Works, High Path, London, S.W.19. Among these items will be smoke density indicator and alarm equipment, Flamestat flame failure protection equipment, and level controllers of various types, including a recently-introduced photo-electric modulating unit. A photo-electric counter to be shown incorporates the company's Spadlock plug-in chassis arrangement, and has a maximum operating speed of 800 counts per min. Another exhibit, which will be demonstrated, is a photo-electric pre-selected batching counter.

The Pyrostat temperature controllers made by the company are available with operating temperatures from 300 to 750 and from 750 to 1,500 deg. C., and are particularly intended for use with induction and dielectric heating equipment, which provides for rapid work heating. One of these temperature controllers will be shown in operation. The company's print-registration unit, for use in the packaging industry, has recently been the subject of some design improvements, and the latest type, which will be on view, incorporates a combined optical head and plug-in chassis.

A new product which will be exhibited by

Isotope Developments, Ltd., Beenham Grange, Aldermaston Wharf, near Reading, Berks., will be the type 656 gamma switch, illustrated in Fig. 4. Suitable for such duties as level control, detection of the interface between two liquids, and detection of flow failure, this switch comprises, essentially, a Halogen-quench Geiger-Muller tube and a relay, which are connected by printed wiring in the chassis, and are housed in a weather-proof body. Measuring only 11 by 10 by 4 in., the switch can be connected to a mains supply of 200/250 volts, and the contact of the relay can be coupled to a conventional control circuit. The relay is operated when gamma radiation of a predetermined intensity is detected by the Geiger-Muller tube. The switch is intended to be mounted externally on hoppers, tanks, and pipes, for instance, and since no probes, floats, or electrodes are employed, it is unnecessary to cut holes in a vessel.

Among the exhibits of Sperry Gyroscope Co., Ltd., Great West Road, Brentford, Middx., will be included a new Introview instrument for detecting flaws and corrosion in the bores of tubes for steam condensers and heat exchangers. A new servo-driven instrument, to be displayed, is designed to indicate, on a single dial, the position, to within 0·004 in., the direction of movement, and the speed of a control rod in a nuclear reactor. Attention may also be drawn to a new sensitive electro-hydraulic valve for servo mechanisms, which can be operated by a current of a few milliamperes and will control fluid deliveries up to 10 gal. per min. The valve will be demonstrated in conjunction with an electric sensing unit and a hydraulic cylinder, to indicate the suitability for precision copying equipment. A.C. transducers, which will be shown, are available in two types, to enable electric signals to be obtained from rotary and linear movements. These transducers may be used as sensing devices, gauging elements, and, on machine tools, for producing follow-up signals for a servo system. Another exhibit will be a differential pressure transducer for medium-pressure applications (up to 1,000 lb. per sq. in.), which has a flame-proof, corrosion-resistant body, to meet specified requirements for certain types of process control duties.

On the stand of Siemens Edison Swan, Ltd., 155 Charing Cross Road, London, W.C.2, will be shown a new type of inserted valve socket, and a range of inter-panel connectors for use with printed wiring systems. A recently-introduced range of valve-holders will also be on view, together with examples from the company's extensive range of stabilized power supply units. Another exhibit will be a self-contained industrial servo unit which provides accurate control of speed and position. This display will also include various types of transistors, power valves, telecommunication equipment, and relays. Although primarily intended for use in telephone exchanges, the digit switch Uniselector which will be exhibited finds numerous applications in automatic control systems and computors.

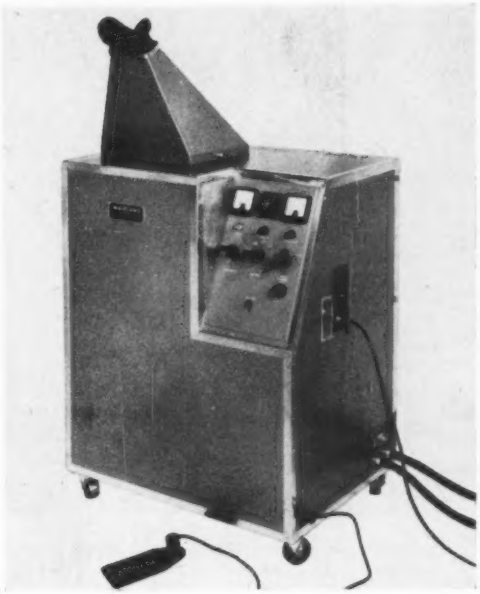
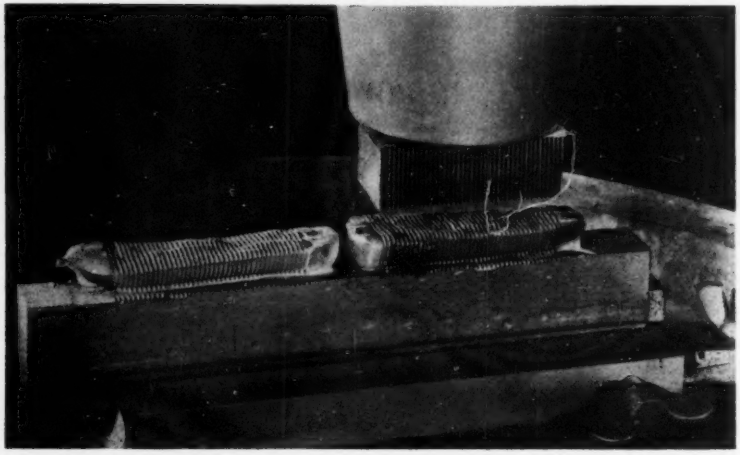


Fig. 5. Marconi Fluoroscopic and Radiographic Inspection Equipment

Marconi Instruments, Ltd., St. Albans, Herts., will exhibit the equipment illustrated in Fig. 5, which is intended for the direct visual examination of small parts by X-ray fluoroscopy and can also be employed for radiographic inspection. A 12-in. long by 12-in. wide by 5-in. deep drawer is provided for accommodating the work to be inspected, and there is a separate drawer which will take film cassettes up to 12 by 10 in. If required, large parts can be mounted separately for radiographic inspection. Current outputs up to 110 kVp. 10 mA. are available, with water cooling, and controls are conveniently grouped on a sloping panel at the right of the fluoroscopic viewing head. The lead-lined frame is mounted on castors.

On the stand occupied by Black Automatic Controls, Ltd., Leafield, Corsham, Wiltshire, will

(*Continued on p.* 865)



Some Recent Applications of Ultrasonic Machining

By J. WELCH*

Ultrasonic machining is now being increasingly employed for a variety of operations, and any suitable machine tool can be adapted for the purpose by providing a frequency generator and transducer. In one instance, a Gallmeyer-Livingston hydraulically-operated surface grinder was arranged for ultrasonic machining by replacing the grinding wheel and spindle by a Sheffield Cavitron transducer and its mounting.

The modified surface grinder, with a workpiece having an experimental turbine-blade root form clamped to the table, is shown close up in Fig. 1. The tool is applied in the normal manner for ultrasonic machining of hard material, and an oscillating movement is imparted to the table. By repeatedly passing the work to and fro beneath the formed tool, as it is fed downwards, an excellent surface finish is obtained, with parallel root faces.

The finish produced on the work depends, in general, on the grain size of the abrasive in the slurry. Fig. 2 shows an arrangement whereby two different slurry mixtures can be supplied to the work. One container has a coarse abrasive (No. 280 grain size) for roughing holes, ports, or cavities; the other, a fine abrasive (No. 800 grain size), for finishing. Some typical tool-holders are seen in the foreground.

* Sheffield Corporation, U.S.A.

A set-up for machining rectangular holes in an aircraft hydraulic servo-valve sleeve is shown in Fig. 3. The sleeve is held in an indexing fixture which provides for angular setting. Two ports are machined simultaneously by means of separate tools. The specified tolerance on the distance between the two tools is maintained by holding them in a precision fixture while they are soft-soldered to the tool-holder.

Photomicrographs show that the structure of heat-treated steel is not changed by the ultrasonic cutting process. On the other hand, steel is not machined so readily by this method as are harder and more brittle materials. In this connection, it may be noted that a simple die for making a ring component was produced in cemented carbide in 2 hours 40 min. For a similar die, in steel of 60/62 Rockwell C hardness, 5 hours 20 min. was required. It follows that designers can now use certain materials in the products that had previously to be avoided because there was no suitable method of machining them.

The ultrasonic process has proved particularly effective for making dies for type, and has enabled the output of such dies to be increased as much as 25 times, while maintaining the same standards of quality. A carbide type die can now be machined by the ultrasonic method in 20 sec.

Ultrasonic machining has also been employed successfully for producing carbide extrusion dies. The carbide die in Fig. 5 is about 1 in. thick. It was made by the ultrasonic method, in a fraction of the time formerly required, from a solid blank by using tapered and straight tools to form the entrance angle, the relief on the outside of the throat, and the throat. The same method has been used for making new wire drawing dies, and for opening out worn dies to the next larger size.

Progressive blanking dies for intricate forms can also be made by the ultrasonic process, to avoid the need for making the tool in many small sections, which must then be assembled in a retaining plate. By machining from the reverse side, a small clearance angle is automatically obtained in the opening.

Fig. 2. This Ultrasonic Machine has Separate Slurry Systems for Roughing and Finishing. A Typical Group of Tool-holders is Seen in the Foreground

Designs can be machined ultrasonically in gem stones, spinel, and similar materials. The engraving of medallions for decorative purposes is usually performed on very brittle materials for which the cutting time is short. Rates of penetration as high as 0·001 to 0·020 in. per sec. can be obtained, and each tool may be used to cut as many as 300 parts.

In another instance, a square hole and a tapped hole were machined in a piece of diamonite, which is cut fairly readily by the ultrasonic method. For this purpose, soft-steel tools were used in Monel tool-holders. To tap a thread, the workpiece may be mounted on a rotary table which can be raised by a lead-screw. In this way, the work is rotated and fed upward on to the fixed tap.

Other practical applications for the process include the slicing and dicing of silicon and germanium for transistors and diodes used in motor-car wireless sets, hearing aids, and various other electronic devices. By similar methods, white sapphire is sliced and diced to form jewel bearing blanks. In the heading illustration is shown a tool which makes a number of

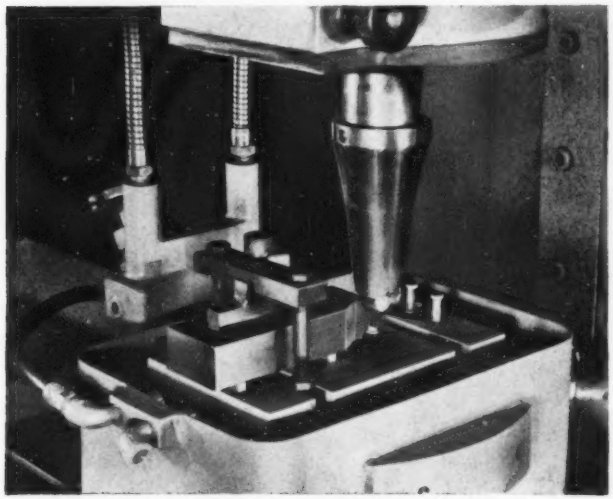


Fig. 1. A Standard Surface Grinder Converted for Ultrasonic Operation. The Work is Traversed Past the Vibrating Form Tool

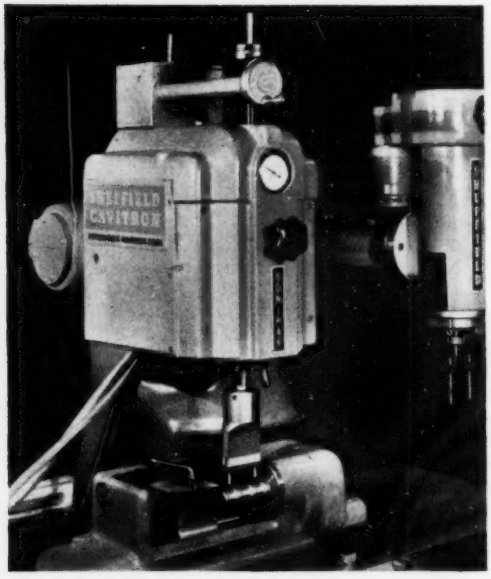
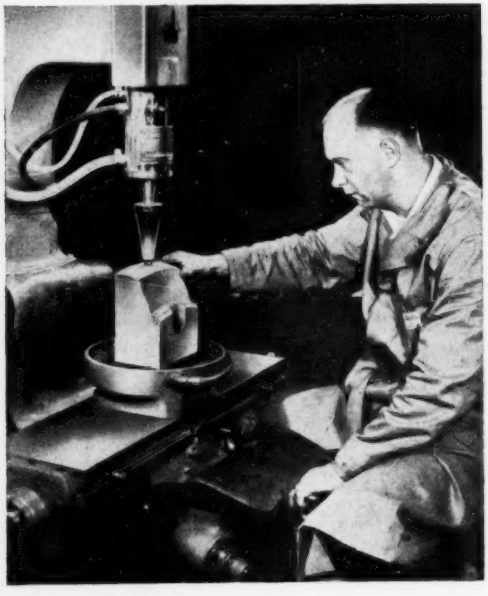


Fig. 3. Rectangular Ports in an Aircraft Hydraulic Servo-valve Sleeve are Machined Two at a Time with this Set-up

Fig. 4. (below) Ultrasonic Machining of Cavities in Segmental Plaster Tyre Patterns Avoids the Necessity for a Tedious Hand Carving Operation



parallel cuts simultaneously to slice a piece of sapphire into thin wafers. Each wafer is 0·020 in. thick and has smooth sides. The wafers are then diced or cut into small roundels. For the latter purpose, the ultrasonic tool comprises a bundle of drawn steel tubes, brazed together.

Thread designs for motor-car tyre moulds that were formerly difficult to produce to the required accuracy are now being obtained rapidly and economically with ultrasonic equipment. Cavities are machined in segmental plaster tyre patterns, such as that seen in Fig. 4, to receive stainless-steel mould inserts whereby complex tread designs are produced, which improve road holding qualities and reduce tyre noise. Previously, these cavities were hand-carved in the plaster and this

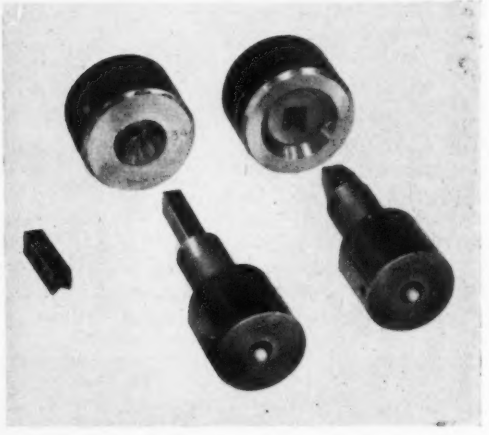


Fig. 5. Views, from both Ends, of a Carbide Extrusion Die which was Machined from a Solid Blank with the Straight and Tapered Tools Seen in the Foreground

operation occupied much time. With ultrasonic machining, however, the cavities are cut to the correct depth and are accurately located. Previous troubles due to chipping, misalignment, and distortion, have been eliminated, together with the design limitations which they imposed.

Like glass, ferrite is normally a difficult material to machine. One assembly, used in large numbers in electronic computers, requires a ferrite toroid with an 0·0015-in. slot cut through one side. This slot is being successfully machined by the ultrasonic method. Another application of ultrasonic machining to this material is illustrated in Fig. 6. The component, a saturable reactor core, is pro-

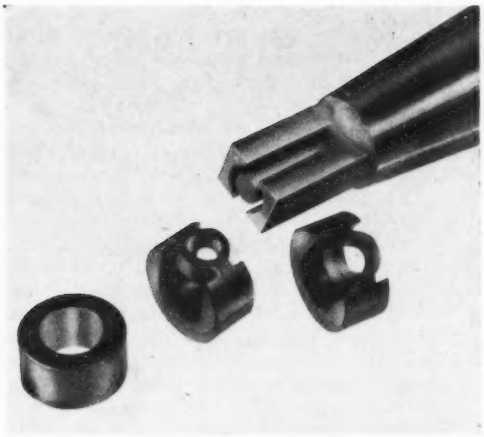


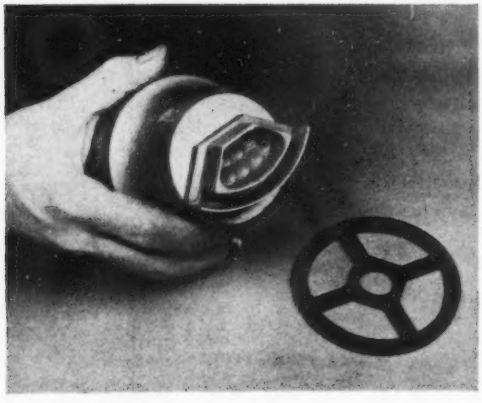
Fig. 6. Saturable Reactor Cores which were Machined Ultrasonically, to Close Tolerances, from Ferrite Rings

duced from a ring with the tool shown. The previous method of production resulted in excessive scrap losses.

Wheel-shaped components have been produced from Ferramic, another hard and brittle material, by the use of the trepanning type of tool seen in Fig. 7. This tool required a minimum of stock removal, and high cutting rates were obtained.

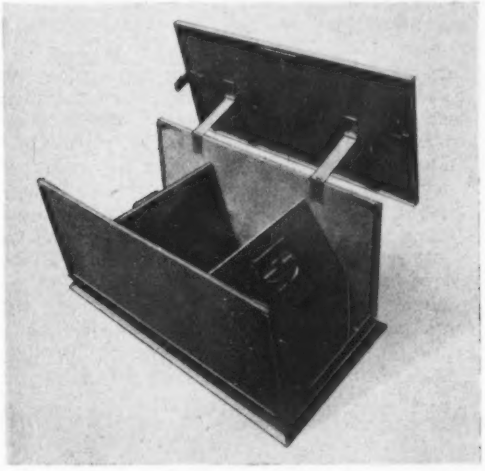
For engraving by hand, a small ultrasonic tool is available which incorporates a pencil-type transducer. This portable tool is used for profiling, polishing, cutting, and drilling, and is powered by a 20-watt electronic generator which operates on 115/120 volt, 60-cycle, single-phase current.

Fig. 7. Wheel-shaped Component Produced from Ferramic in Four Operations with a Trepanning Type Tool



Retemba Collapsible Containers

The Retemba collapsible container, here shown in the partly-assembled condition, has recently been introduced by Warwick Production Co., Ltd., Birmingham Road, Warwick. With a frame of extruded aluminium alloy and panels of weather-proofed plywood, the container has an internal length of 30 in. and a depth of 15 in. It is available in widths of 15 and 22½ in., and the weights of the two sizes are 29 and 37 lb. Other sizes can be made to suit requirements.



View of the Retemba Collapsible Container in the Partly-assembled Condition. It has an Aluminium Frame and Weather-proof Plywood Panels

Attached to the base by hinges, the panels are locked in the vertical position by spring-steel clasps at the top corners. The lid is permanently attached to one side panel by pivoted brackets, and is secured to the end panels by automatic clip fasteners with quick-release toggles. Handles of cadmium-plated steel are fitted to the end panels for lifting purposes.

When the container is folded completely flat, it can be conveniently handled and stored, and there are no loose parts.

Binns & Berry Type JB Centre Lathe

The accompanying illustration shows the type JB 10½-in. centre lathe which has recently been developed by Binns & Berry Bros. (Halifax), Ltd., Ovenden, Halifax. It has been designed to combine high performance and accuracy with ease of operation. A length of 6 ft. is admitted between the centres, and the swing capacity over the full length cross-slide is 12 in. Work up to 35 in. diameter by 11 in. wide is admitted in the gap.

Measuring 17 in. across the shears, the bed is 10 ft. 6 in. long, and has a wide sloping guideway at the front, for the saddle, and an inverted V-guide at the rear, for the tailstock. The bed has chilled ways, and there is a stepped seating for a removable half-gap piece. To facilitate swarf removal, the sheet steel tray can be half withdrawn, if required. The coolant sump, is located in the headstock cabinet casting, together with the motor-driven pump and the electrical control panel.

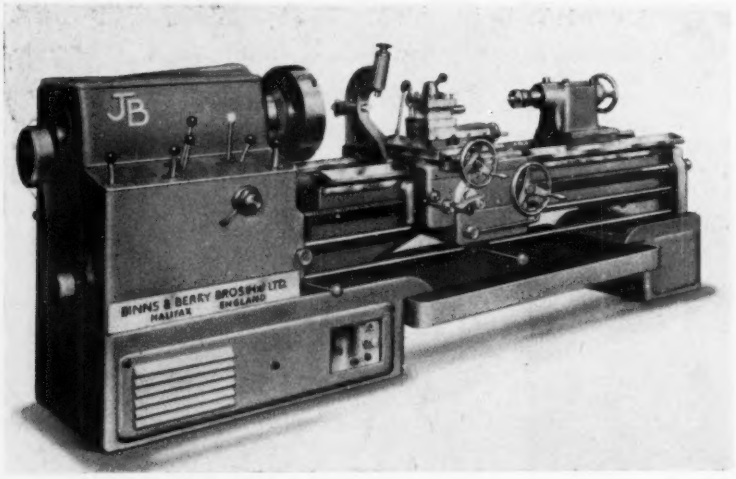
Drive is taken from a 10-h.p. motor, through V-ropes, to a large diameter pulley and Anderton heavy-duty friction clutch. Control levers for starting and stopping the lathe are located adjacent to the gearbox and beneath the apron. The all-geared headstock has a readily-detachable cast aluminium lid, and all the gears are machined from forgings of K.E. 805 steel, which are oil-hardened to 70 tons tensile strength before the teeth are finish cut. Shafts in the headstock are also of K.E. 805 steel, and all splines are ground. Pressure lubrication is provided for the bearings and gears.

Ball or roller bearings are employed for the headstock shafts, and Angus insert oil seals are fitted to shafts which project through the casting. The forged steel spindle, which is bored to pass a 3-in. diameter bar, is mounted in twin Timken precision roller bearings, and the nose is fitted with a centre bush and No. 4 Morse taper centre. There are 18 spindle speeds, ranging from 15 to 750 r.p.m.

The saddle has long bearing surfaces on the bed, and the surfacing slide has a sufficient length of traverse to face work up to 33 in. diameter at one setting of the tool. Both the surfacing slide and saddle can be locked securely in position, and the saddle is fitted with felt wipers. The compound tool rest can be swivelled through 360 deg., and the slides have micrometer adjustment. In the figure, the lathe is seen fitted with a square steel turret toolpost, with one face arranged to receive boring bars and drill adapters, but other types of tool rests are available, if required.

Of double-walled construction, the apron houses the large-diameter, phosphor-bronze feed worm wheel. The worm-box has snap-action control for the engagement and disengagement of the feed, and there are levers on the front of the apron for selecting sliding, surfacing, or screwcutting motions.

A quick-change totally-enclosed, feed and screw-cutting gearbox, with lever and dial controls, provides 60 changes of sliding feed, from 0·002 to 0·128 in. per rev., 60 surfacing feeds, from 0·001 to 0·056 in. per rev., 60 Whitworth threads, from 1 to 56 per in., and 43 Metric pitches, from 0·5 to 28 mm. With an extra set of end driving gears, 35 diametral pitches from 2 to 56



Binns & Berry Bros. Type JB 10½-in. Centre Lathe

D.P., and 27 circular pitches from $\frac{1}{8}$ to 1¾ in. can be obtained. The shafts in the gearbox are mounted in ball or roller bearings, and pressure lubrication is provided by means of the oil pump in the headstock.

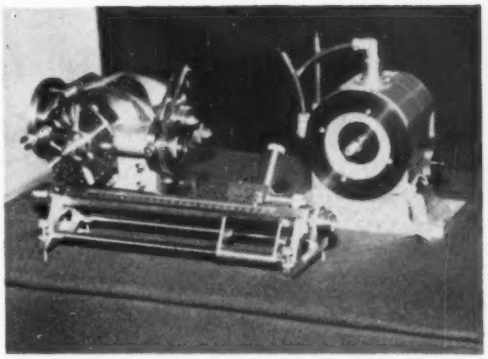
Set-over adjustment is provided for the tailstock for turning of small tapers, and the spindle, which is shown fitted with a ball-bearing centre, is locked by a pad bolt. The floor space occupied by the machine is 11 ft. 6 in., by 4 ft., and the approximate weight is 54 cwt.

London Association of Engineers

More than 200 members and guests attended the 106th Anniversary Festival Dinner of the London Association of Engineers, which was held at the Criterion, Piccadilly, London, W.1, on March 28. The toast to "The Engineering Industry, Coupled with the Name of the London Association of Engineers" was proposed by the chairman, who, on this occasion, was Rear-Admiral Sir C. Philip Clarke, K.B.E., C.B., D.S.O., M.I.E.E., M.Brit.I.R.E., a director of the J. Langham Thompson Group. The speaker stated that it was in keeping with the progressive outlook of the Association that they had invited a radio engineer to act as their chairman. He pointed out that electronic engineering would play an increasingly important part in the industrial activities of this country in the future, and expressed the opinion that electronic means should be employed wherever they would allow a task to be done better, or in less time, than was possible through the agency of an operator. The electronics industry, the speaker mentioned, had achieved a new record for exports in 1957, with twice the volume of those for 1947, and ten times the volume of those for 1937.

Rear-Admiral Clarke emphasized the importance of the men who were responsible for the management of engineering workshops, and drew attention to the fact that the brilliant results of the work of scientists and designers had to be put into production, and that our prestige in the markets of the world depended on the quality of our products. He felt that the London Association of Engineers was doing excellent work in encouraging young engineers to aim for, and maintain, high standards of craftsmanship, and considered that the entries for the annual apprentices competition were of remarkable quality.

In his reply to the toast, the President of the Association, Mr. F. W. Witt, stated that the rules of the competition required each entrant to submit drawings of the workpiece submitted and a thesis on some aspect of engineering practice. He pointed out that the standard of craftsmanship this year had been good, generally, and that the final selection had depended to a large extent on the drawings and written work. Mr. Witt introduced the three prize winners, who received their awards from Rear-Admiral Clarke. The winning workpieces are seen in the accompanying illustration.



The Entries for the Annual Apprentices Competition Organized by the London Association of Engineers were again of a Very High Standard, as is Evident from these Prize-winning Workpieces. The First Prize was Awarded to Mr. R. I. Mugford (C.A.V., Ltd.) for the Dividing Head (left), the Second Prize to Mr. C. Levi (C.A.V., Ltd.) for the Indicator Box (right), and the Third Prize to Mr. T. E. Voyce (Marconi's Wireless Telegraph Co., Ltd.) for the 50-ohm Slotted Line (centre)

In proposing the toast to the guests, Mr. A. H. Pane, Vice-President of the Association, drew attention to Rear-Admiral Clarke's outstanding achievements in connection with the anti-submarine branch of the Royal Navy. He extended a welcome to the numerous delegates from allied associations in various parts of the country, and emphasized that the Association had always tried to encourage young men of the right type to enter the engineering profession, and to work diligently in order to achieve the highest positions. Mr. R. W. Boardman, director of F. W. Bridges & Sons, Ltd., responded on behalf of the guests.

STANDARD TYPEWRITERS produced during September, October and November, 1957, totalled 10,355, 14,624, and 10,633 respectively. The corresponding figures for the production of portable typewriters were 10,912, 14,114, and 12,644, and exports of both types during these months totalled £1,011,000. For comparison, machines exported in the last quarter of 1956 were valued at £1,329,000.

News of the Industry

Hull

J. H. FENNER & CO., LTD., Marfleet, are experiencing a steadily-maintained demand, from both home and overseas customers, for V-belts and pulleys, including the new Premium V-belts which incorporate polyester fibres, taper-lock pulleys and bushes, torque-arm shaft-mounted speed reducers, variable-speed units, and single, duplex, and triplex chain sprockets and roller chains. A 232-page catalogue has recently been issued describing the firm's comprehensive range of mechanical power transmission equipment. Various Fenner products are to be shown at the Mechanical Handling Exhibition, at Earls Court, London, from May 7 to 17, and at the Chemical and Petroleum Exhibition, at Olympia, London, from June 18 to 28.

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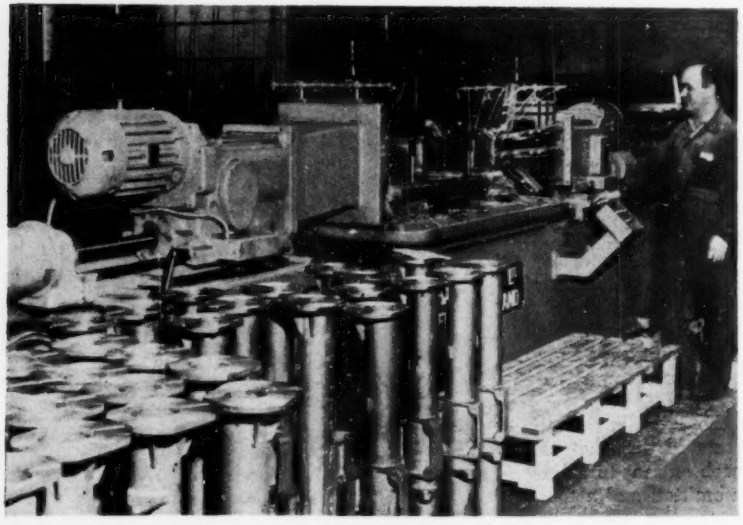
KINGSTON ENGINEERING CO., LTD., Dansom Lane, are engaged in the production of a variety of transmission screws, in a wide range of sizes, and with threads of square, Acme, and buttress forms. Orders are in hand for lathe lead screws, friction press screws and nuts, and extruder screws for plastics machinery. Screws of lengths from 20 to 40 ft. are being successfully jointed. Our attention was drawn to some special worm threads cut on 54-in.-long shafts, of $\frac{5}{8}$ in. diameter. These shafts are for use in accounting machinery, and on each there are 15 3-start worms. Orders are also in hand for special-purpose machinery, and worn parts are being reclaimed by metal spraying.

ROSE, DOWNS & THOMPSON, LTD., Old Foundry, have a good order book for a wide variety of equipment, much of which is destined for export. We may note the recent delivery of a fish meal plant to Canada, and two plants for hardening oil for cooking fats, to Pakistan. In addition, an oil refinery plant has just been completed for Jordan. An order has recently been booked for oil-mill machinery, valued at about £250,000, for installation on the Continent, in face of severe competition from foreign manufacturers. Nearly 50 Maxoil Duplex continuous oil expellers are involved, and the machines are to be installed in oil mills in Holland and Belgium, for expelling oil from palm kernels and copra, to produce margarine oil, cooking fats, and animal feeding stuffs.

Other activities at



This Kitchen & Wade double-ended, horizontal drilling machine is being used at the works of Bristol Commercial Vehicles, Ltd., Bath Road, Brislington, Bristol, 4, for machining holes, ranging up to $\frac{31}{64}$ in. diameter, in the end flanges of chassis cross-members. There are two K. & W. No. 2 unit heads with multi-spindle units. Each multiple unit has six spindles which are bored No. 1 Morse taper, and the positions of the spindles are individually adjustable. The heads provide four spindle speeds, from 259 to 506 r.p.m., and there are four rates of feed, from 119 to 204 cuts per in. An automatic operating cycle provides for rapid advance to the cutting position; drilling at the pre-selected rate; rapid return; and stop. The heads can be traversed independently or simultaneously, and the capacity of the machine is such that it provides for drilling cross-members with overall lengths ranging from 8 ft. 6 in. to 2 ft.

these works include the production of blast-furnace auxiliary plant on behalf of Ashmore, Benson, Pease & Co., Ltd., machine tool sub-contract work, and special equipment for the Atomic Energy Authority. Since our last visit, additional plant has been installed in the machine shop, including a Butler 14-in. stroke production slotting machine, a Snow vertical spindle, 48- by 18-in. reciprocating table, surface grinding machine, a Churchill 25-in. swing HCY internal grinding machine, a Marco metal bandsawing machine, and a Parkinson Sunderland No. 19 gear planing machine, of 54-in. diameter capacity. In the toolroom, a Jones-Shipman tool and cutter grinder, and an 18- by 6-in. surface grinder, also a Butler 4-in. precision slotter, have been added. Recent pattern-shop additions include a Sagar bandsawing machine and a Wadkin wood-tool grinding machine.

This firm has recently introduced to Great Britain a new and patented process for the external cladding of rolls, shafts, tubes and drums with stainless steel and other hard wearing and corrosion resisting materials. The process has been fully proved on the Continent, and is said to give a sound bond and complete protection to all surfaces exposed to corrosion. Clad rolls can be keyWayed, ground and polished, and they are suitable for operation at temperatures from −40 to 300 deg. C. Corrosion resistant rolls and shafts made by this process permit a considerable saving in cost. Clad rolls can be supplied complete. Alternatively, the cladding process can be applied to customers' rolls and shafts, and machining, grinding, and polishing can then be undertaken.

PRIESTMAN BROTHERS, LTD., Holderness Engineering Works, hope to complete the transfer of their business to the new factory at Marfleet in the late summer. Much plant has already been moved, and it is expected that the commercial offices will be the last section affected. There has been some reduction in the demand for excavators, grabs, and dredgers in recent months, both on home and export account. Orders in hand cover grabs and dredgers for New Zealand, and bulk-handling equipment for sugar, which is destined for Scotland.

RICHARD SIZER, LTD., Cornwall Street, are occupied with a variety of gear-cutting work, which includes spur, bevel, worm and single-helical gears. In addition to the standard fan-cooled worm reduction units in hand, we may note two types of 3-stage bevel and spur gear reduction boxes, for use in conveyor drives. Other activities include the production of cubing machines for animal feeding stuffs.

HULL GAUGE & TOOL CO., LTD., Beverley Road, are busy with the production of drill jigs and milling fixtures, for builders of armoured vehicles, aircraft, marine diesel engines, steam turbines, electrical machinery and industrial power plants, also gas turbine blade tooling equipment and fixtures. In addition, orders in hand for press tools and receiver gauges. Our attention was drawn to a sturdy and accurate machine vice, with 8-in. wide jaws and a 12-in. length capacity, which is being produced in batches for toolroom use. Recent plant additions include a Clarkson tool and cutter grinder, and a Churchill 12- by 36-in. universal grinder, equipped with Philips universal clarifier, is due for delivery shortly. This firm is A.I.D. approved, and has a cinema for the regular display of technical films to employees.

PARSONS BROTHERS, LTD., Froghall Lane, Sutton Road, in addition to the production of metal closures and other components for the tin box and container trades, are now producing large quantities of screwed metal caps for bottles, for which additional presses and screwing equipment have been installed. A steady demand is reported for black and bright bolts and nuts, washers, studs, tie rods and coach screws for railway work, also for jigs, fixtures and press tools for the tin box and other trades. H. B.

Instruments, Electronics and Automation Exhibition

(*Continued from p.* 857)

be shown a new range of diaphragm-operated valves, in sizes up to 3 in. B.S.P., which are intended particularly for handling a wide range of industrial fluids, including grease and wax. Three- and four-way valves for compressed air and hydraulic systems operating at pressures up to 5,000 lb. per sq. in. will also be exhibited, together with the firm's range of pressure switches, which has recently been extended to include units for operation at pressures up to 10,000 lb. per sq. in. Other items will include solenoid-operated valves for gas supplies and oil-burning equipment.

Laurence, Scott & Electromotors, Ltd., Norwich, will display a wide range of Magslips, synchros, and industrial- and instrument-type tacho-generators. Of particular interest will be a mechanical scanning system for use with the Kelvin-Hughes Autosonics equipment for the non-destructive testing of metals for internal defects at speeds up to 150 ft. per min. The Autosonics equipment was described in MACHINERY, 90/666—22/3/57. Another exhibit will be a magnetic amplifier for the control of variable-speed motors.

Engineering Manufacture Conference

To draw attention to the considerable developments which are taking place in manufacturing techniques in the metal-working industries, and to stimulate interest in the scientific aspects of production, The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1, recently held a three-day conference on the Technology of Engineering Manufacture, which was opened by the president of the Institution, Sir George H. Nelson. There were six technical sessions at which some 60 papers were presented, including a number from the U.S.A., Russia, and other countries, and 850 engineers and executives registered for attendance. Because of the large number of papers involved, the organizing committee, under the chairmanship of Dr. D. F. Galloway, again decided to adopt the system of presentation by reporters, who briefly introduced the papers for discussion. Authors were given the opportunity to answer questions towards the ends of discussion periods. Frequently, however, because so many took part in the discussions, oral replies were necessarily restricted to a few minutes each.

Sessions on the first day were devoted to forming of materials, and included papers on recent investigations into the blanking and piercing of sheet materials, the contribution of brazing in light engineering, principles of static-dynamic forging, and investigations concerned with the impact extrusion of aluminium, copper, and steel. On the second day, machining of materials was discussed, and the titles of papers included: certain results of work in the field of mechanics of the metal-cutting process (a Russian contribution), machining of titanium alloys, recent developments in broaching, turning with ceramic and sintered oxide tools, and the machining of corrosion- and heat-resistant steels and alloys.

Inspection techniques were the subject of the final day, and papers were concerned, for instance, with weld inspection, and a 3-dimensional tape-controlled inspection system. The conference concluded with a general discussion, during which Dr. W. A. J. Chapman, principal of Hatfield Technical College, expressed the view that more attention must be paid to the development of forming processes, and that this method of manufacturing parts would be used on an ever-increasing scale for producing components at present made by the use of cutting tools.

Abstracts of some of the papers presented will be published in later issues of MACHINERY, and will be concerned, for example, with blanking and piercing, impact extrusion, and ceramic tools.

B. & K. Laboratories Exhibition

The fourth in the series of exhibitions of electric and electronic instruments and equipment, organized by B. & K. Laboratories, Ltd., 57 Union Street, London, S.E.1, was held recently at Caxton Hall, London, S.W.1. More than 60 firms from Great Britain, the U.S.A., and several Continental countries displayed a wide range of products including oscilloscopes, magnetic tape reading and recording equipment, strain gauges, pressure, torque and displacement transducers, and load cells.

The Danish firm of Brüel & Kjaer exhibited their type 6100 dial-indicator roughness tester which can be set, by a single rotary switch, to give full scale readings of 0·3, 1, 3, 10 and 30 micro-metres and 10, 30, 100, 300 and 1,000 micro-inches, in arithmetic average values. It is hoped to publish full particulars of this instrument in a forthcoming issue of MACHINERY.

Multi-conductor cable in tape form which has recently been developed by the Tape Cable Corporation, U.S.A., was also shown. Of 0·0015 by 0·03 in. cross section the copper conductors have a rating of 1 amp. at 300 volts A.C., and are set 0·1 in. apart in 0·008-in. thick transparent polyester insulating material. The insulating material can be readily stripped from one or both sides of the conductors for a short distance at the ends of the cable in preparation for making connections. The subject of a patent application, the cable is particularly intended for connection to printed circuits and is available in different widths with from 9 to 50 conductors. It is supplied in lengths from 25 to 1,000 ft. A 100-ft. length of cable incorporating 30 conductors, for example, weighs only 100 lb.

Desoutter Die Set Drawings

Desoutter Bros., Ltd., The Hyde, Hendon, London, N.W.9, have produced the first of a series of printed full-scale outline drawings for the most popular types in their range of standardized die sets. These prints are intended to facilitate the work of jig and tool drawing offices. After a press tool drawing has been made, the draughtsman can select the most suitable die set shape, place the print under the drawing, and trace the outline.

Alternatively, the die set shape outline may be traced first, and the press tool is then drawn within the outline.

Apart from the outline drawings, each sheet gives the leading particulars for the die set or sets

represented, and indicates the die spaces available in all the sets of that range.

The drawings now available cover most sets with die spaces up to 5⅝ in. diameter for circular types, 8 by 3½ in. for rectangular types, and 7 by 5 in. for square types. Outlines for larger die sets will be ready for distribution in the near future.

Sets may be obtained, free of charge, from the above address.

New Premises for Richard Lloyd

In the illustration is shown a view of Galton House, Elmfield Avenue, Tyburn, Birmingham, 24—the new head office of Richard Lloyd, Ltd., which was formally opened recently by the Lord Mayor of Birmingham, Alderman J. J. Grogan.

A stores department occupies most of the ground floor, and at the rear there is a 150-ft. long loading bay for lorries. Facilities are provided for servicing the firm's fleet of 50 vehicles, and the area of the site will permit extension of the premises later, if required. On the ground floor there is also a reception hall and a well-appointed showroom where the extensive range of Galtona cutting tools, made at the company's works at Tenbury Wells, Worcs., is displayed, together with examples of the small tools and grinding wheels which are handled.

Sales and accounts staff occupy a single spacious office on the first floor, and there are adjoining offices for executives. Staff dining and recreation rooms are provided on the top floor of the building.

The New Head Office Building of Richard Lloyd, Ltd., in Elmfield Avenue, Tyburn, Birmingham, 24. On the Ground Floor there is a Stores Department and a Showroom

Letters to the Editor

[The Editor does not hold himself responsible for the views expressed by his correspondents.]

The Millionth of an Inch

[To the Editor of MACHINERY]

SIR,—In MACHINERY, 92/628—14/3/58, Dr. J. C. Evans proposed the abbreviation 1μin. for one millionth of an inch, for which I suggested 1m″.

The objections put forward to 1m″ seem academic, certainly m stands for metre on occasion, and ″ for a second of angle, but the context and one's common sense prevent confusion. No one, for example, reading that the error in the length of a slip gauge is 3m″ could imagine that the unit is either a metre, which is forty million times too large, or a thousandth or millionth of a second of angle, which is exceedingly small and is an angle, not a length.

The objections to 1μin. are practical. The absence of μ from a standard typewriter is a serious nuisance. Technical typists handle virtually everything that appears in print and a vastly greater amount that does not, and their convenience should not be brushed aside. Also μ is not included in the ordinary shop vocabulary. But we are all familiar with £1M, meaning a million pounds, and it comes naturally to use 1m″ for a millionth of an inch—big M for million, little m for millionth.

Esperanto has been described as the universal language that nobody speaks, and we risk a similar failure in the technical field unless we really do consider the common good, the man in the shop, and the typist. Such a failure has already occurred in the case of the thousandth of an inch. B.S. 350:1944 gives "1 mil. = 0·001 inch," but does not everyone reject this foreign word and speak of the English thou?

In other fields one readily agrees that the Greeks were peerless and their tongue appropriate, as in the case of a new unit introduced

recently in a *Financial Times Supplement*. This unit of beauty, or milli-helen, is defined as "disturbing enough to launch just one ship." Like μ, it seems hard to handle.

ALAN BROWNE.

Blackdown Mill, near Leamington

* * *

Addition of Greek Letters to a Typewriter

[To the Editor of MACHINERY]

SIR,—I was interested in the letter by Mr. J. C. Evans in MACHINERY, 92/628—14/3/58. It seems that the same objection has been raised on several fronts, namely that whereas the use of Greek letters may be satisfactory in print, there is always the trouble of the original typescript.

I am an electrical engineer and have found the same shortage as our mechanical brethren, when using the same letter for "micro-," as in microfarad. Other letters sadly missed are "pi" and "omega."

It is not sufficiently widely realized that most makers will, in fact, supply almost any type required at quite moderate cost. By sacrificing the little used fractions (one can still write 3/4, 7/16, etc.), three keys are released which can be suitably modified. The actual changes, of course, will depend on the user, but I have had mine converted to $+=$; π ω; and $\sqrt{\ }$ μ. Such expressions as $j\omega L$, $\omega = 2\pi f$, μF., or μ sec. can thus be typed without the usual pen and ink additions. Where $+=$ are already present, two more letters or symbols could be incorporated.

The range of a full technical typewriter is not, of course, achieved, but on a small portable, this simple and fairly inexpensive modification has, I feel, been worth while.

F. W. J. CLARK.

Portsmouth.

Coming Events

INSTITUTION OF ELECTRICAL ENGINEERS.—*East Midland Centre.* April 15, at 6.30 p.m., at Loughborough College; discussion on "The Application of Digital Techniques to Control." *Northern Ireland Centre.* April 15, at 6.30 p.m., at the Civil Engineering Department, David Keir Building, Queen's University, Belfast; paper on "An Asymmetrical Induction-motor Winding for 6 : 3 : 2 : 1 Speed Ratios," by Prof. G. H. Rawcliffe, M.A.

INCORPORATED PLANT ENGINEERS.—*Blackburn Branch.* April 17, at 7.30 p.m., at the Golden Lion Hotel, Blackburn; paper on "Work Study in the Smaller Factory," by P. A. Gibbs, M.A. (Oxon.).

JUNIOR INSTITUTION OF ENGINEERS.—April 18, at 7 p.m., at the Institution, Pepys House, 14 Rochester Row, Westminster, London, S.W.1; paper on "A Review of P.E.R.A. Activities," by R. L. Hayward.

Trade Publications

CONSOLIDATED PNEUMATIC TOOL CO., LTD., 232 Dawes Road, London, S.W.6.—Catalogue describing the range of chisels for use with pneumatic hammers, riveters, and cutters. This publication forms the fourth section of the company's accessories catalogue, and gives detailed information on 38 types of chisel.

REDIFON, LTD., Broomhill Road, London, S.W.18. The latest issue of *Redifon News Letter* (No. 21) draws attention to the progress and achievements of the company during the first 25 years of its existence. Illustrations are included of the factory and head office at Wandsworth, the flight simulator factory at Crawley, the Communications Laboratory, the Electronics Control Division building, and the Rediweld factory.

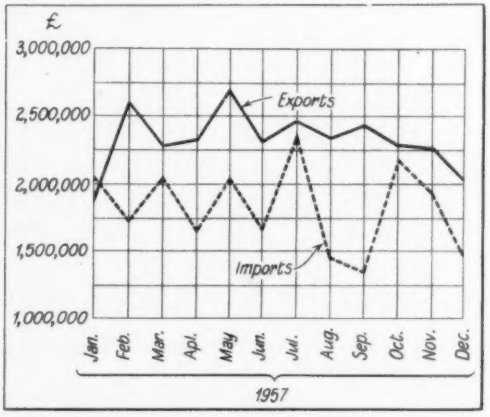
Deckel Exhibition and Demonstration

An exhibition and demonstration of the new Deckel optical co-ordinate LK machines is to be held at the Mackadown Lane works of B.S.A. Tools, Ltd., from April 21 to 25 (10 a.m. and 4 p.m. daily). For the purpose of the demonstration a basic LK machine will be employed on which will be mounted, alternately, equipment for jig boring and jig grinding.

Other machines to be seen at this exhibition will include the Deckel type FP2 tool milling machine, the KF1 pantograph die sinking machine and the GK21 pantograph profile milling machine.

Machine Tool Imports and Exports

The accompanying graph shows the monthly fluctuation in exports and imports of machine tools during the year 1957.



Personal

MR. E. T. R. BALL, A.M.I.E.E., has been appointed managing director of The British Electric Transformer Co., Ltd., Clayton Road, Hayes, Middlesex.

MR. W. E. A. WILLIAMS has been appointed technical representative for London and South-East England for Suffolk Iron Foundry (1920), Ltd., Stowmarket, Suffolk. He will operate from 100 Preston Lane, Tadworth, Surrey (telephone number, Burgh Heath 6536).

MR. ALFRED REEDER has recently been appointed general manager of J. H. Fenner & Co., Ltd., Marfleet, Hull, after 33 years' service with the company. Last year he completed an assignment connected with the starting of the firm's manufacturing operations in Madurai, South India.

MR. O. T. EVANS, Assoc. M.C.T., A.M.I.Mech.E., A.M.I.E.E., was recently appointed chief engineer of the Electrical General Engineering Department of Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17. This department comprises the Mining and Rolling Mill Divisions.

MR. J. C. HELLIAR, who was formerly the Southern Region representative for Thomas Mercer, Ltd., Eywood Road, St. Albans, Herts, has been appointed sales manager of the Air Gauge Division. MR. D. G. CARTER has been appointed representative for the Northern part of the Home Counties and East Anglia, and Mr. F. M. HARVEY for the Southern part of the Home Counties and South East England.

MR. T. HERD, who, for the past 12 years, has been manager of the Birmingham office of Brook Motors, Ltd., Empress Works, Huddersfield, has been appointed general manager of the company's London sales office. Mr. Herd served an apprenticeship with the firm, and subsequently held the post of sales engineer at Manchester for 4½ years. He was manager at the Newcastle-on-Tyne sales office from 1930 to 1946.

MR. MONTY PRICHARD, M.C., deputy managing director of F. Perkins, Ltd., Peterborough, has been appointed joint managing director of the company with MR. FRANK PERKINS, who now becomes chairman and joint managing director. Mr. Perkins, who founded the company in 1932, has decided to relinquish some of his executive responsibilities. Mr. Prichard joined the firm as personal assistant to Mr. Perkins in 1953, and became a director, in charge of engineering, in 1954. He was appointed deputy managing director in 1956.

BOROUGH POLYTECHNIC LECTURERS.—As a result of the introduction of advanced technological courses, the following appointments have been made to the teaching staff of the Borough Polytechnic, Borough Road, London, S.E.1. Senior lecturers in mechanical engineering MR. C. E. T. MAGUIRE, B.Sc. (Eng.), A.C.G.I., A.F.R.Ae.S., and MR. J. F. DOUGLAS, M.Sc. (Eng.), B.Sc. (Eng.), A.C.G.I., D.I.C., A.M.I.C.E., A.M.I.Struct.E.; lecturer in mechanical engineering and metallurgy, MR. R. A. C. SLATER; senior lecturer in physics, MR. G. F. FILBEY, B.Sc., A.Inst.P.; and lecturer in electrical engineering, MR. J. S. VOSPER, B.Sc. (Eng.), A.C.G.I., A.M.I.E.E.

Developments in Plastic Deformation Processes

(*Continued from page* 815)

subject, that the normal limits for blank size were about 1 in. diameter by 6 to 9 in. long, and although the shapes produced by this method are commonly symmetrical, it is also applicable to various unsymmetrical forms. As in the case of impact extrusion, components should be designed with a knowledge of the process, so that features likely to cause difficulty can be avoided.

It has been fully established that even ferrous metals, initially at room temperature, can be caused to flow under pressure, suitably applied, to a much greater extent than was formerly thought possible. There are now various processes whereby this characteristic can be turned to practical account, and it is important that they should be adopted, where suitable, in the interests of manufacturing efficiency. In addition to improvements in cold deformation techniques, some of which have been noted, important developments are taking place in connection with the hot deformation processes. The general trend is towards reductions in the amounts of material to be removed by machining, and plastic working may also have the advantage of substantially improving the properties of a material.

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11/4/58

Industrial Notes

EMPLOYMENT IN THE MACHINE TOOL AND ENGINEERS' SMALL TOOL INDUSTRIES declined from 121,400 at the end of 1956 to 119,800 at the end of 1957. Of the latter total, 98,300 were males.

GEORGE COHEN SONS & CO., LTD.—The Raw Materials Division of this company has moved to Trinity Road, Kingsbury, Tamworth, Staffs (telephone numbers, Hurley 821/2 and Ashfield 1191/3: telegraphic address, Omniplant, Tamworth).

AN AUCTION SALE OF MACHINE TOOLS and miscellaneous stores from the Technical Stores Depot, Old Dalby, will be held in Melton Mowbray, Leicestershire, on May 7 and 8. The auctioneers will be Shouler & Son (Dept. N), 1 Norman Street, Melton Mowbray.

NU-SWIFT, LTD., Elland, Yorkshire, have introduced a new dry powder fire extinguisher, known as the type 1630, which is claimed to be particularly effective for fires involving inflammable liquids, high-voltage electrical equipment, and oil-fired boilers. It provides a fan-shaped, pressure-projected powder spray.

STEEL AND IRON PRODUCTION IN FEBRUARY.—The Iron and Steel Board states that steel production in February averaged 427,500 tons a week, compared with 407,100 tons in January, and 432,100 tons in February, 1957. Pig-iron production in February was at the rate of 272,700 tons a week, compared with 271,000 tons in January, and 267,600 tons in February, 1957.

UNIVERSAL METAL PRODUCTS, LTD., Langley Road, Salford, 6, Lancs., are producing spade-handle type grips for heavy industrial switchgear. These handles, which are supplied to Metropolitan-Vickers Electrical Co., Ltd., are moulded from plastics material filled with glass fibre, and offer the advantages of high electrical resistance, thermal insulation, and shock resistance.

A "RESPONSIBILITY" CONFERENCE FOR JUNIOR ENGINEERS —the fourth of an annual series—was recently arranged by the United Steel Companies, Ltd., 17 Westbourne Road, Sheffield, 10. This conference was held at Cambridge under the chairmanship of Sir John Hunt and was attended by 110 apprentices and junior operatives from various branches of the company, who heard talks by industrial and education authorities and took part in discussion groups.

W. DAVID & SON, LTD., 47-49 Caledonian Road, London, N.1, are now marketing in this country a synthetic rubber coating for application to factory floors, which is claimed to be durable and dustproof, and to improve comfort and reduce noise. Known as Liquid-Rubba it contains Goodyear Pliolite and can be supplied in various colours. It is stated that it can readily be applied to floors of various types.

THE LIGHTFOOT REFRIGERATION CO., LTD., Abbeydale Road, North Circular Road, Wembley, Middlesex, inform us that they have developed a new range of packaged water chilling units, to meet the requirements of air conditioning engineers and industrial users of chilled water. These units are available in capacities from 10 to 100 h.p., and the smallest has overall dimensions of 6 ft. by 4 ft. by 3 ft. 9 in.

OUTPUT OF PLASTICS.—At the recent annual meeting of the British Plastics Federation, the president, Mr. H. V. Potter (Bakelite, Ltd) said that, given reasonable trading conditions, there was no "limiting target yet in sight for the expansion of the United Kingdom plastics industry" Output of plastics last year was estimated at 400,000 tons, valued at approximately £110 million. This tonnage exceeded that of 1956 by nearly 20 per cent.

THE INDUSTRIAL WELFARE SOCIETY (INC.), Robert Hyde House, 48 Bryanston Square, London, W.1, will hold a one-week course for foremen and forewomen, at the above address, from April 28 to May 2. The course will give instruction in handling people and there will be a minimum of lecturing. Instead, the emphasis will be on practical exercises in speaking, interviewing, group discussion leading, report writing, and study in groups.

INSTRUMENT DISPLAY AT S.I.M.A. HOUSE.—The eighth display in the exhibition room at S.I.M.A. House, 20 Queen Anne Street, London, W.1, the headquarters of the Scientific Instrument Manufacturers' Association of Great Britain, was recently opened. Products of 18 members firm are on view, and it may be noted that the Cambridge Instrument Co., Ltd., are showing almost all the instruments which they recently displayed at the Interkama exhibition in Dusseldorf.

RYE-ARC, LTD., North Woolwich Road, London, E.16, are fabricating six large autoclaves for the Thermolite factory in Birmingham. Each autoclave will be 105 ft. long by 7 ft. 2 in. inside diameter, and will weigh 45 tons. Of all-welded construction, the outer shells will be of $\frac{3}{4}$ in. plate and the dished and flanged ends, of $\frac{13}{16}$-in. plate. The first of these autoclaves was recently delivered by road by Annis Transport and the travelling time was three days. When installed, the autoclaves will be steam heated, and will be fitted with internal tracks to receive loaded wagons.

VAUXHALL MOTORS, LTD., Luton, report that their sales turnover in 1957 amounted to £76 million. Exports during the year totalled 84,422 units with a value of £38 million, and accounted for 59 per cent of total output. Abnormal conditions were experienced as a result of the very large expansion programme which has been undertaken. It is pointed out, however, that the heavy expenditures are virtually complete and that 1957 was an important milestone "which marked the transition to a much higher level of business activity in the future."

THE GENERAL ELECTRIC CO., LTD., Magnet House, Kingsway, London, W.C.2, and LUMENATED CEILINGS, LTD., Alliance House, Caxton Street, London, S.W.1, have agreed to combine design and development resources to provide a service for the marketing and application of Lumenated ceilings. An example of recent co-operation between the two companies is a 3,500-sq. ft. ceiling which

provides the main illumination in the new exhibition hall of the British Motor Corporation, Ltd., Longbridge, Birmingham.

CROMPTON PARKINSON (STUD WELDING), LTD., 1-3 Brixton Road, London, S.W.9, announce that a second cash award of 1,500 dollars—or 2,000 dollars in scholarships for any individual or school of the winner's choice—will be given for what is judged to be the year's most outstanding contribution in the field of semi-automatic electric arc stud welding.

Gegory Industries Inc., Lorain, Ohio, U.S.A., who are licence associates, are sponsoring the competition, and entry forms and full particulars may be obtained from the British company.

MERCIA ENTERPRISES, LTD., Godiva House, Allesley Old Road, Coventry, inform us that they have been appointed sole British distributors for the range of rubberized abrasive wheels, points, sticks, blocks, and cones, made by Cratex Mfg. Co., California, U.S.A. It is claimed that the cushioned action of these products facilitates smoothing, polishing, cleaning, de-burring and similar operations. Literature available from the above address is concerned with the full range of products available, and typical applications, also with a polishing kit.

Machine Tool Share Market

Stock markets were generally cheerful during the period under review. Prices advanced steadily in most sections, and there was some expansion in the volume of business.

An outstanding feature was the increasing strength of the market for British Funds, also Home Corporation and Dominion Stocks. Here, quotations advanced as a result of sustained investment demand, and finished at the highest levels recorded.

In the commercial and industrial sections, the tendency was bright, and there was an upward trend due to selective demand and restricted market supplies of stock. Moreover, several firm features developed following good dividend announcements.

Machine tool issues were quietly steady. Chas. Churchill advanced 1½d. to 4s. 6d.; John Harper, 6d. to 14s.; Kerry's (Gt. Britain), 6d. to 6s. 6d.; and Thos. W. Ward, 9d. to 75s. On the other hand, Armstrong Stevens lost 3d. at 7s.; Newman Industries 3d. at 2s. 6d.; Birmingham Small Arms, 6d. at 24s.; and Churchill Machine Tool, 6d. at 17s. 6d.

COMPANY		Denom.	Middle Price
Abwood Machine Tools, Ltd.	Ord.	1/-	9d.
Armstrong, Stevens & Son, Ltd.	Ord.	5/-	7/-
Allen (Edgar) & Co., Ltd.	Ord.	£1	28/3
" " "	5% Prf.	£1	14/6*xd
Arnott & Harrison, Ltd.	Ord.	4/-	14/-
Asquith Machine Tool Corp., Ltd.	Ord.	5/-	16/6
" " "			ex rights
	6% Cum. Prf.	£1	17/9
Birmingham Small Arms Co., Ltd.	Ord.	£1	24/-
" " "	5% Cum. "A" Prf.	£1	15/6
" " "	6% Cum. "B" Prf.	£1	17/6
" " "	4% 1st. Mort. Deb.	Stk.	85/-
British Oxygen Co., Ltd.	Ord.	£1	34/-
" " "	6½% Cum. Prf.	£1	21/6
Brooke Tool Manufacturing Co., Ltd.	Ord.	5/-	5/6
Broom & Wade, Ltd.	Ord.	5/-	9/9
" " "	6% Cum. Prf.	£1	17/9
Brown (David) Corporation, Ltd.	5½% Cum. Prf.	£1	14/4½
Buck & Hickman, Ltd.	6% Cum. Prf.	£1	17/6
Butler Machine Tool Co., Ltd.	Ord.	5/-	6/3
" " "	5% Cum. Prf.	£1	13/9
C.V.A. Jigs, Moulds & Tools, Ltd.	5½% Red. Cum. Prf.	£1	13/9
Churchill (Charles) & Co., Ltd.	Ord.	2/-	4/6
" " "	6% Cum. Prf.	£1	26/3†
Churchill Machine Tool Co., Ltd.	Ord.	5/-	17/6
" " "	6% Cum. Prf.	£1	18/9
Clarkson (Engrs.), Ltd.	Ord.	5/-	11/-xd
Cohen (George), Son & Co., Ltd.	Ord.	5/-	11/6
" " "	4½% Cum. Prf.	£1	14/6
Coventry Gauge & Tool Co., Ltd.	Ord.	10/-	12/9
" " "	5% Cum. Red. Prf.	£1	16/3
Coventry Machine Tool Works, Ltd.	Ord.	4/-	9/-
Craven Bros. (Manchester), Ltd.	Ord.	5/-	6/-
Elliott (B.) & Co., Ltd.	Ord.	1/-	3/-
" " "	4½% Red. Cum. Prf.	£1	13/9
Export Tool & Case Hardening Co., Ltd.	Ord.	2/-	1/6
Firth Brown Tools, Ltd.	4% Cum. Prf.	£1	12/3
Greenwood & Batley, Ltd.	Ord.	£1	46/10½
Harper (John) & Co., Ltd.	Ord.	5/-	14/-
" " "	4½% Red. Cum. Prf.	£1	13/1½
Herbert (Alfred), Ltd.	Ord.	£1	62/6
Holroyd (John) & Co., Ltd.	"A" Ord.	5/-	10/6
" " "	"B" Ord.	5/-	9/9
Jones (A. A.) & Shipman, Ltd.	Ord.	5/-	21/3xd
" " "	7% Cum. Prf.	5/-	5/-
Kayser, Ellison & Co., Ltd.	Ord.	£1	45/-
" " "	6% Cum. Prf.	£1	18/3
Kendall & Gent, Ltd.	Ord.	5/-	7/9
Kerry's (Gt. Britain), Ltd.	Ord.	5/-	6/6
Kitchen & Wade, Ltd.	Ord.	4/-	10/3
Martin Bros. (Machinery), Ltd.	Ord.	2/-	2/4½
Massey, B. & S., Ltd.	Ord.	5/-	7/3
Modern Engineering Machine Tools, Ltd.	Ord.	5/-	10/-
Newall Engineering Co., Ltd.	Ord.	2/-	5/-
Newman Industries, Ltd.	Ord.	2/-	2/6
" " "	6% Prf. Ord.	5/-	5/6
Noble & Lund, Ltd.	Ord.	2/-	4/9
Osborn (Samuel) & Co., Ltd.	Ord.	5/-	16/3
" " "	5½% Cum. Prf.	£1	24/6
Pratt (F.) & Co., Ltd.	Ord.	5/-	20/6
Scottish Machine Tool Corporation, Ltd.	Ord.	4/-	5/3
Shardlow (Ambrose) & Co., Ltd.	Ord.	£1	32/-
Shaw (John) & Sons, Wolverhampton, Ltd.	Ord.	5/-	11/7½
Sheffield Twist Drill & Steel Co., Ltd.	Ord.	4/-	35/-
" " "	5% Cum. Prf.	£1	15/-
Stedall & Co., Ltd.	Ord.	5/-	4/6
Tap & Die Corporation, Ltd.	Ord.	5/-	7/9
" " "	4½% Deb. 1961-1977	Stk.	82/-
Wadkin, Ltd.	Ord.	10/-	18/9
Ward (Thos. W.), Ltd.	Ord.	£1	75/-
" "	5% Cum. 1st. Prf.	£1	15/6
" "	5% Cum. 2nd Prf.	£1	24/6
Willson Lathes, Ltd.	Ord.	1/-	2/4½

The Middle Prices given in the list are in several cases nominal prices only and not actual dealing prices. Every effort is made to ensure accuracy, but no liability can be accepted for any error. * Sheffield price. † Birmingham price.

PRICES OF MATERIALS

All prices per ton except where otherwise stated.

Pig-Iron

Foundry and Forge No. 3, Class 2

Middlesbrough zone	£21 6 0
Birmingham	£20 18 3

Phos. 0·1 to 0·75%

Birmingham	£23 17 0

Scottish Foundry

Grangemouth	£25 3 6

Hæmatite

English No. 1

N.E. and N.W. Coast	£25 6 6
Scotland	£25 13 0
Sheffield	£26 15 0
Birmingham	£27 4 0

Welsh £25 6 6

Steel Products

Medium plates	£45 11 6
Mild steel plates, ordinary*	£42 2 0
Boiler plates*	£44 12 0
†Flat bars 5 in. wide and under } †Round bars under 3 in.	£40 0 6
Billets, rolling quality, soft U.T.	£32 15 6

Phosphor Bronze

Ingots (2B8) (A.I.D.) d/d £240 0 0

Copper

Cash (mean)	£172 12 6
Cold rolled and hot rolled sheets 4 ft. by 2 ft. by 10 SWG	£243 0 0—£243 10 0
Rods $\frac{3}{16}$ in. to $\frac{3}{4}$ in. diam.	£266 5 0
Tubes, 1½ in. bore by 10 SWG, ton lots, per lb.	2s. 6½d.
Wire rod, black, hot-rolled ($\frac{1}{4}$–$\frac{7}{16}$ in.) English	£191 2 6

Zinc

Refined, minimum 98 per cent. purity, current month (mean) £61 13 9

Brass

Tubes, solid drawn, per lb.	1s. 5½d.
Strip 63/37, 6 in. by 10 SWG coils, ton lots	£210 0 0—£212 10 0
Rods, ½–3 in. diam. (59 per cent copper)	1s. 8½d.

Yellow Metal

Condenser plates, per ton	£148 0 0
Rods, per lb.	1s. 9½d.

Aluminium

Ingots min. 99·5 per cent Canadian d/d	£180 0 0

Lead

Refined, minimum 99·97 per cent purity, current month (mean) £71 12 6

Tinplates

‡U.K. Home trade:

Handmill f.o.t. makers' works	£3 11 8½
Cold reduced, f.o.t. makers' works	£3 7 4½

U.K. Export:

Hot rolled basis, f.o.t. works' port	74s. 0d.—76s. 0d.
Cold reduced basis, f.o.t. works' port	76s. 0d.

Gunmetal

Ingots, 85.5.5.5. ex works‖ £155 0 0

* N.E. Coast, N. Joint Area, Central Scottish Zone.

† U.T. soft basic.

‡ Official maximum price, after allowing for adjustments for increase in price of tin.

MAKERS' PRICES

Hexagon Steel Bars[1]

Sizes in inches from 1 in. up to 2·21 and 2·41 a/f, ex works 2 ton basis	£42 17 0
Free cutting black	£47 6 6

Reeled Steel Bars[1]

Single-reeled 1½ in. upwards, f.o.t. works (+ usual extra for sizes)	£43 9 6
Free cutting	£47 19 0

High-Speed Steel

Black random length bar. All prices basic, per lb., subject to extras.

Molybdenum "66"	5s. 10½d.
Molybdenum "46"	5s. 8½d.
14 per cent tungsten	5s. 9d.
16 per cent tungsten	6s. 1½d.
18 per cent tungsten	6s. 4d.
22 per cent tungsten	7s. 5d.
5 per cent cobalt 4·75/5·25 per cent molybdenum + 6·0/6·75 per cent tungsten + 1·75/2·05 per cent vanadium (5-6-2)	9s. 6d.

Precision-ground, High-speed Free-turning Brass Rod[2]

½-in. dia. ± 0·00025-in. 2-ton lots, per lb.	2s. 2½d.

Grey Iron Rod

Die Cast[3] in random lengths 18 in. to 24 in. rough machined ½-in. above listed size. Extra for definite lengths, for hardenable alloy iron, and for orders of less than £50. Discounts for orders over £150.

	Per cwt. net. Mark I	Mark III
¼ or ⅜ in.	255s. 6d.	318s. 10d.
1 or 1½ in.	204s. 4d.	251s. 10d.
1½ to 1¾ in.	143s. 0d.	171s. 2d.
1⅞ to 2 in.	106s. 2d.	125s. 11d.
2¼ to 3¼ in.	91s. 6d.	106s. 4d.
3¼ to 12 in.	86s. 6d.	99s. 2d.

Continuous Cast

10-ft. lengths, centreless machined 1 to 3-in. dia. + 0·010 to 0·020 in., prices as quoted for die cast bar[3]

6-ft. lengths centreless ground + 0·010 in. Extra for hardenable alloy iron[4] Per cwt. net	¼ or ⅜ in.	245s. 4d.
	1 or 1½ in.	196s. 4d.
	1½ to 1¾ in.	137s. 10d.
	1⅞ to 2 in.	106s. 2d.
	2¼ to 3 in.	91s. 6d.

Stellite[5]

Welding Rods plain

¼ in. dia. per lb.	30s. 0d.

Toolbits

¼ in. sq. × 4 in., each	22s 3d.

Precision-ground Mild Steel[3]

1-in. dia. + 0·00025-in. 4-ton lots, per cwt.	121s. 6d.

[1] Colvilles, Ltd., Glasgow, and 17 Grosvenor Street, London, W.1. [2] Pratt, Levick & Co., Ltd., Chester. [3] Sheepbridge Alloy Castings, Ltd., Sutton-in-Ashfield. [4] "Flocast," Harold Andrews Sheepbridge, Ltd., Halesowen. [5] Deloro Stellite, Ltd., Highlands Road, Shirley, Solihull.

BASIC PRICES FROM LONDON STOCK[6]

Free Cutting Steel

Bright cold drawn: (Usaspead) over 1½ to 2 in.	£59 17 6
Lead bearing (Usaled)	£64 4 0
Precision ground, 1¾ in.	£81 12 6

Bright Drawn

M.S. bars (M.M.C.) over 1½ in. to 2 in.	£55 3 6
Square edge flats (Usaflat)	£72 0 0
M.S. angles (Usaspead)	£99 10 0
Casehardening (EN) (Usacase) over 1½ in. to 2 in.	£63 9 6
M.S. bars (EN3B) (Usamild) over 1½ to 2 in.	£57 3 6
Carbon manganese semi-freecutting case hardening (EN202) (Usaspead 202) over 1½ to 2 in.	£72 19 0
35/45 ton tensile (EN6) (Usen) over 1 to 1½ in.	£64 17 6
0·4 Carbon Normalised (Usaspead "40") over 1½ in. to 2 in.	£66 19 6
Carbon manganese steel to Specification EN.16.T (Usaspead 5565), per ton	£127 11 3

Ground Flat Stock

18-, 24-, and 36-in. lengths (Usaspead). List prices less 5 per cent

Oil Hardening Cast Steel

Non-shrink (Usaspead N.S.O.H.) ¾ in. to 2¾ in., per lb.	1s. 11d.
Non-distorting heavy duty (Usaspead H.C.H.C.) ¾-in. to 2¾-in., per lb.	4s. 2d.

Silver Steel

(0·194-in. to 1¼-in.) Genuine Stubs quality, per lb.	4s. 6d. less 27½%
M.M.C. quality, per lb.	2s. 5d. + 6½%
Boxes of 16 assorted sizes $\frac{1}{16}$-in. to ¾-in. dia.	7s. 6d.

Stainless Steel

K.E. 40.AM (Freecutting), per lb. 3s. 3½d.

Glacier Machined Bronze Bars

Phosphor bronze (2B8) } Lead bronze } Prices on application

High-speed Steel

18 per cent tungsten. Prices on application.

Toolholder bits:

Usaspead "Super" } ,, "Supreme" } ,, Cobalt 10 } List price

Shimstock

Steel assorted, per tin	3s. 6d.
Brass ,, ,,	7s. 3d.

[6] Macready's Metal Co., Ltd., Pentonville Road, N.1. Subject to confirmation by London Office. Delivered free by van in London area.